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By Robert H. Peters and Louis Schaffer

UNITED STATES DEPARTMENT OF THE INTERIOR

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft	foot
h	hour
in	inch
lbf	pound (force)
min	minute
mt	metric ton
mt/h	metric ton per hour
oz	ounce
oz/mt	ounce per metric ton
pct	percent
yr	year

FIELD TESTS OF A MODEL HEALTH AND SAFETY PROGRAM FOR THE MINING INDUSTRY

By Robert H. Peters[1] and Louis Schaffer[2]

ABSTRACT

The objective of the project descibed in this report was to design and field test a model health and safety program at a coal mining company and a gold mining company. The model program was implemented primarily by providing training on loss control, accident investigation, and the operation of mobile equipment; and by providing technical assistance to help solve health and safety problems. Data were obtained from company records on occupational injuries, illnesses, accidents, and "near misses"; and through direct observation of employees performing a large number of randomly selected jobs. At the coal mine, employees were observed five times over a 15-month period. At the gold mine, employees were observed six times over a 16-month period. During the study, the percentage of sampled jobs containing one or more safety deficiencies decreased from 74.3 pct to 36.6 pct at the coal mine and from 86.4 pct to 19.1 pct at the gold mine. Work on this project was performed by Woodward Associates, Inc., under a Bureau of Mines contract.

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INTRODUCTION

During the past 20 yr, significant progress has been made in the improvement of health and safety conditions in mining. The Federal Coal Mine Health and Safety Acts were established in 1969 and 1977, and the mining industry has greatly increased its emphasis on health and safety. Nevertheless, mining is still recognized as an industry that has a high incidence of accidents and injuries.

According to the National Safety Council (*1*),[3] the mining industry experienced 8.68 work injuries per 200,000 employee-hours worked, compared to a 1979 all-industry average of 7.76. The incidence rate for bituminous coal was 8.83, and for metal mining the rate was 12.27.

These statistics show that further improvements must be made if mining is to be removed from the list of high-risk industries. More effective methods for reducing occupational injuries and illnesses are needed. Therefore, the objective of this research effort was to develop and field test a model health and safety program that will assist mine managers in concerted efforts to reduce accidents and health hazards in the mining industry.

Most mining companies practice some form of accident prevention or reduction. The 1977 Health and Safety Act sets mandatory training standards for miners and requires mining companies to administer federally approved health and safety training programs, but there are no Federal guidelines for establishing and maintaining formal, comprehensive health and safety programs. Many different methods and approaches are being used throughout the mining industry to reduce accidents, depending upon the size of the company, its labor force, and other available resources; type of mining technology and product; and management's attitude toward safety. However, little information exists as to which specific methods and approaches are effective. It was because of this lack of information that the Bureau of Mines contracted for the research described in this report. One of the overall goals was to better define the essential features of effective health and safety programs for the mining industry. Therefore, the initial phase of this research was directed toward reviewing existing accident reduction methods and approaches available in mining and other similarly hazardous industries, evaluating those methods or program elements, and recommending a comprehensive model program that could be used to improve health and safety throughout the mining industry. The intent was to identify and correctly define only those health and safety program elements that have proven to be successful and have the potential for universal application throughout the mining industry. The final phase of the research was to field test the model health and safety program at two mines.

The project began in September 1980 and was completed in April 1983. It consisted of a sequence of four research tasks, as follows:

Task 1. Generation of baseline data

Task 2. Assessment of existing health and safety practices

Task 3. Development of a model health and safety program

Task 4. Implementation and validation of the model health and safety program.

Although the most salient results of tasks 1 and 2 are described in the next section, this report deals primarily with the results of tasks 3 and 4. For a complete account of the literature review and field observations that preceded the development of the model (tasks 1 and 2), see the final report on this project (*2*).

This report includes a presentation of the most important findings from the literature review and field observations, a description of the model program and a plan for evaluating it, an explanation of how the model program was implemented at two mining companies, a description of the results of more than a year of program evaluation, and recommendations and conclusions. The appendixes contain excerpts from the model programs tailored to each of the two mining companies and some examples of the job performance sampling data.

This report is based on work performed by Woodward Associates, Inc., under Bureau contract HO308076.

BACKGROUND RESEARCH

This section describes the preliminary research that was conducted to gather background information prior to the actual field implementation of the model health and safety program.

The background research included–

Several types of literature searches seeking material related to mining health and safety programs and recommended practices.

Discussions with recognized experts in the mining safety and health fields.

Examination of available data on results acheived through various safety policies and practices.

Observation and assessment of health and safety management in mining and in two other industries with some similar equipment and job hazards.

[3] Underlined numbers in parentheses refer to items in the list of references preceding appendix A.

These activities are discussed in detail in the final report (*2*). Here, only the findings that had a significant influence on the definition of model program are briefly discussed.

The majority of safety management books reviewed, and many of the articles by safety experts in professional journals, emphasize that workplace safety and work force health are management responsibilities like all other responsibilities related to the business enterprise. Petersen (*3*) notes that one principle is perhaps more important than any of the others: Safety should be managed like any other company function. The field observations made by the researchers as part of task 1 affirmed this principle. The mining operations that had the safest working conditions and the greatest degree of worker conformance to safe work practices were those operations in which safety was managed like any other company function and all of the company functions were managed well. There were a few operations in which safety and all other company functions were managed poorly. The majority of the operations observed

did not treat safety and health in the same way as other functions. Usually these matters had a lower management priority and seemed to be viewed as a cost of doing business, like taxes, or as ways to comply with government regulations, rather than as opportunities to improve productivity and profit.

If safety and health are to be managed in the same manner as other company functions, it follows that safety and health rules and procedures should be defined and enforced in the same way as other kinds of rules and procedures that regulate the company's activities. Some of the safety literature emphasizes this point. Chapman (*4*), a safety engineer for Firestone Tire and Rubber Co., has stated this point clearly: "Let's stop thinking about 'how to do the job' and 'safety' as separate processes. Think only of 'how to do the job the right way,' and be sure the safety rules for that job are fully integrated into all training and are enforced no differently than other procedure rules."

Although some of the mining companies observed had taken small steps in the direction of fully integrated work and safety rules and procedures, most had taken no steps at all. Several had no written rules other than the safety rules. The idea of fully integrated work and safety rules is not reflected in the policies commonly found in the mining industry. In contrast, fully integrated work and safety rules are accepted as "the only way" in industrial and governmental organizations for jobs in which an accident could produce disastrous results. Space; nuclear power; air transportation; military air, undersea, and missile operations; and surgery and medicine are among the industries and activities in which there are many jobs with fully integrated safety rules and procedures. Hammer (*5*), a well-know aerospace safety expert, has identified certain criteria to be observed in the preparation of safety rules. One criterion is that "safety rules for a particular operation and for the workers involved should be included in the procedures for the conduct of that operation." Examination of several aerospace operator's manuals indicated that this criterion was satisfied. Examination of job procedure manuals prepared by a few large, progressive mining companies indicated that this criterion was also satisfied in those manuals. However, among the operations observed, the usual situation was that work procedures and safety rules were separately developed and separately taught. Only in enforcement was full integration observed – and then only at the job supervison or section supervisor level.

Both field observations and the research literature suggest that one of the fundamental conditions for an effective health and safety program is full integration with all work procedures and rules. Without such integration, truly effective management of safety and health is unnecessarily difficult – perhaps impossible.

Among the companies observed, some had good safety and health conditions and no safety officer. Some had poor safety and health conditions and no safety officer. Some had good conditions and a safety officer, and some had poor conditions and a safety officer. It was evident that the presence of a safety officer, by itself, had very little to do with the safety and health results achieved. In the context of total loss control management, the safety office itself would have to be considered a loss at a few of the mining companies visited. Money was being spent for something that was not being received.

Partlow (*6*) notes that 25 or 30 years ago it was not unusual to find that the safety practitioner had the job because he or she had been injured on his or her previous job. At one mining company, the employee relations manager was asked how the company's safety official was selected. He replied that the employee had been hurt in an accident and that "there wasn't any other job he could do here." This suggests that management was not handling well the management functions of planning, organizing, staffing, direction, and control with respect to safety and health. Furthermore, the top manager was doing a poor job of demonstrating his interest in, and commitment to, job safety – a commitment he had announced publicly in a policy letter several months earlier. Other responses to questions about how the safety official was chosen included the following:

He had some spare time in his job as supply clerk, and he had served as a sergeant in the military service.

He used to be a policeman.

We wanted to keep him as a junior geologist, but he wasn't satisfied with his pay. We were able to increase his pay by assigning him additional responsibilities in safety.

We decided to have a safety man and to fill the job internally. He was the best of the three who were considered.

We hired him as kind of a management trainee. The safety job is a good place for him to get an overall view of the operation.

He was a security guard who did a good job. He wanted to improve himself so he asked to be promoted to safety. He's really not our safety officer because we don't have one authorized. He's called a "safety technician."

He has some college and he speaks Spanish, so he can talk to some of our miners who can't speak English.

It is of fundamental importance to the attainment and maintenance of good safety and health conditions that the top managers regularly show subordinate supervisors and workers that safety and health are among the primary management concerns. Management can demonstrate interest and commitment in many ways; however, any way chosen must satisfy a basic criterion: It must be convincing to the supervisors and workers. How these people perceive management's concern is important. If the manifestations of management interest and commitment are perceived as artificial or insincere, their effect on the attitudes and behavior of the work force is negative rather than positive. Sometimes, well-intentioned and customary ways of demonstrating management concern fail. Chapman (*4*) illustrates this point with an anecdote about three teenagers at a National Safety Congress session:

> When asked if they would read a safety rule pamphlet given to them by their boss, these young people said probably not. If the boss wanted them to understand and follow the rules, they should be explained face to face. If no more interest in their safety was shown than just handing them a pamphlet, they wouldn't think their boss regarded safety as very important, so neither would they.

One of the most convincing ways a top manager can manifest concern for effective safety and health management is to have all subordinate supervisors properly educated in safety and health management. Why then is it that most of the supervisors in the mines observed were not so educated? The probable explanation is that most of the top managers were not themselves formally prepared to

manage safety and health matters. The majority of them were mining engineers or graduates in some other engineering discipline. Interviews with them about their backgrounds in safety and health indicated that they had very limited education, and no direct experience, in these matters. In light of the importance of health and safety to productivity and profits in mining ventures, it appears that the training of most mining industry professionals in these matters is insufficient. As a result, safety officers often have poorly defined duties and, as previously indicated, are selected with little regard for qualifications. Supervisors under such managers generally do not seek to acquire special skills in the health and safety area on their own initiative.

If the top manager has properly executed the planning, organizing, and staffing functions related to safety and health, the direction and control functions are made much easier. This is especially true if the organizational arrangement makes all supervisors fully accountable for safety and health in their departments. This arrangement was a prominent feature of the mining operations that were observed to have the best safety and health conditions.

In the discussion above, the phrase "good safety and health conditions" is used several times without defining what "good" means in this context. Specific evaluative considerations are discussed in the "Field Evaluation Plan" section. It is sufficient here to note several points that are basic to the selection of a measurement for determining the "goodness" of health and safety conditions:

A measurement designed to record personal injury experience is not necessarily a sound way to measure safety performance.

The occurrence of accidents is a probabilistic phenomenon. Management actions that reduce the probability of accident occurrence cannot reduce the probability to zero.

Accidents that produce personal injuries do not necessarily result in a larger total cost to a mining enterprise than those that do not. In most mining operations, the noninjury accidents are far more numerous and their total cost is larger.

As much or more can be learned about accident reduction from accidents that "almost occurred" – that is, "near misses" – as can be learned from accidents that actually occurred (those that are required to be reported to the government).

Contrary to popular belief, it is not true that "unsafe acts" are the cause of 80 to 90 pct of all accidents in mining. The reasons for accident occurrence are much more complex.

The literature review and discussions with experts brought forth a great many ideas that might be candidates for inclusion in a model health and safety program. Nearly every safety practicioner and author had some favorite technique to which he gave credit for whatever accident reduction had been achieved. Often data were presented to show that a reduction in the "MSHA[4] incidence rate" had been experienced during a specified period. Aside from questions about the statistical accuracy and significance of the data, the precise relationship of the data to the variable under consideration could not be determined. It is a rare case when only one element of a company's safety program is altered and the program then remains unchanged for even as long as a year. Nearly every program element alteration or innovation is accompanied by a great many other changes, both obvious and subtle, during its implementation. Even when the variable can be "isolated," there may still be questions about the phenomenon that produced the result. For example, was it the physical improvement of a work area that reduced accidents or was it the so-called "Hawthorne effect"? That is, did the specific physical improvements induce the recorded improvements in work behavior, or did the work behavior results occur because of the workers' response to management's increased attention to them and their workplace conditions? That is, might the results have been the same with entirely different physical improvements?

For almost every safety improvement method advocated by some practicioner, expert, or author, there could be found someone else with apparently equal credentials to impugn the method. For example, there are many advocates of safety contests. Crapnell (*7*) declares that "safety contests and promotions can make safety fun – no small accomplishment in itself." He also quotes a remark concerning "safety bingo" made by a manager of industrial relations: "(It) creates tremendous peer pressure for workers to perform their jobs safely." These statements are representative of many made by persons who use and endorse safety contests. Others raise some questions that the contest advocates usually do not address. Gilmore (*8*) observes that the performance of a plant or work group "cannot really be compared" to that of another plant or work group. Instead, the plant or work group "can show improvement only as it improves its own experience." Of course, contests can be designed so that winning requires the greatest improvement in the group's own experience record. Accurate measurement is necessary, but difficult to achieve. Gilmore points out that "meaningful measurement depends on the sincere desire to learn the truth and is hindered by the desire to appear safer than someone else in a contest situation." Hampton (*9*) observes that, although contests often achieve the intended result, they also produce many unintended results. After citing several actual example, he states, "Neglect, conflict and dishonesty are among the principal side effects of contests. Through defects in design and implementation, contests can implicitly reward activities inconsistent with organizational goals."

The use of safety committees is another practice that some safety experts recommend and others discourage. Mims (*10*) writes, "I have found worker safety committees the most practical way to foster genuine grassroots concerns with safety – the 'they is us' attitude . . . it spreads this feeling of responsibility and safety awareness to every worker who is serving on it or has served on it in the past." However, DeReamer (*10*) opposes the use of safety committees, arguing, "Their basic principle – dispersing responsibility – simply does not work where safety and health is concerned. Employee participation in safety is essential, but there are better ways than committees to achieve it."

In the early part of the background research it seemed appropriate to attempt to select for the model program those *practices* that were favored by the preponderance of available experience, information, evidence, and opinion or supported by especially impressive data. However, soon it became evident that this was not appropriate because –

However successful a given safety improvement is for one or several mining enterprises, it will not necessarily be a sound method in all.

Field observations indicated that very different sets of methods produced similar results at different mines, if both sets were carefully managed.

[4] Mine Safety and Health Administration.

Interviews with experts and field observations led to the conclusion that no single improvement method was essential in a model program to attain and maintain good safety and health conditions. What is essential in a model health and safety program for mines is for management to create and sustain a few fundamental conditions.

DEFINITION OF THE MODEL PROGRAM

This section describes the criteria established for a model health and safety program and then defines the model program in terms of five fundamental conditions.

CRITERIA

The background research work suggested that the model program should satisfy the following criteria in order to be effective and acceptable to mining industry managers:

1. The model must be readily adaptable to all types and sizes of mines in the coal, metal, and nonmetal mining industries.
2. The model should identify all of the essential features for illness and injury reduction effectiveness. All of the essential features are required so that the scope of the model is well known at the beginning of implementation and so that the evaluation does not show an unfavorable result because of program incompleteness. Nonessential features should not be included in the model; they can make the model less acceptable to mine management and the evaluation confusing.
3. The model program must be manageable in ways that are compatible with the management concepts that are customary in the United States. This criterion addresses especially the avoidance of "intervention mechanisms" that require the services of specialists or alter the accountability structure of an organization. The reason for this criterion is primarily to improve the probability of obtaining the cooperation of mining companies in evaluating and, later, adopting the model.
4. The loss reductions attainable through the model program implementation must exceed the cost of the implementation. In 1981-82, the state of the national economy and of the mining economy in particular was such that few mining companies would have been likely to consider any new program unless there was an expectation of a reasonable return on any investment required to implement the program. Safety and health matters are more likely to be dealt with effectively if increased profit is the expected result.
5. The model program should be acceptable to management and labor on its merits alone. No inducement to adopt the program should be necessary, other than the expectation of reduced losses due to accidents and illness. Model program acceptance should be entirely voluntary.

FUNDAMENTAL CONDITIONS

There are many ways in which a model program might be described or defined. The way chosen was to define the model program in terms of a small number of fundamental conditions. All of the conditions can be created and maintained by competent managers in the performance of the normal functions of management.

In framing the model, the research team considered rather carefully what "normal functions of management" means. There are hundreds of management and business administration textbooks and articles that list and explain management functions. One of the most useful lists is presented by Dale (*11*). Dale identifies and discusses seven functions of management:

Planning
Organizing
Staffing
Direction
Control
Innovation
Representation

Dale's list is especially appropriate to mining management because it includes the functions of innovation and representation–functions not included in many other management function listings. Innovation is especially important in mining. Dale notes that management is "a creative rather than adaptive task"–a concept entirely consistent with the model program concepts.

Some methods of defining the model that were considered created problems in satisfying one criterion or another. Satisfying the first and third criterion required the rejection of several ideas for model program features because the ideas were too specific to be acceptable (or useful) to small mines. For examples, many of the experts interviewed advocated a particular organizational pattern for the mine safety office, including a full-time safety official. A typical small mine management would not feel that it could afford the arrangement advocated or that the arrangement was needed. In other words, the small mine management could not foresee a satisfactory return on the investment. The managements of some medium-size mines (say, 50 to 100 miners), and some larger ones as well, might also oppose the arrangement on the grounds that a same, or better, return would be available through a smaller investment.

Another example relates to a proposed model program feature that called for regularly scheduled safety meetings at all levels. It was rejected because it was inconsistent with the first fundamental condition (explained below) and because of a particular finding during the field observations. A mine shift foreman expressed his strong opposition to safety meetings, saying that they were largely a waste of time that they were "rituals" which "gave safety a bad name," and that they dealt publicly with matters which, in his opinion, could be dealt with effectively only in private, one-on-one, supervisory actions. Later it was observed that this foreman had superior safety performance on his shift, as well as an excellent production record. He never conducted formal or informal safety meetings; and some of his subordinates, with a mixture of amusement and admiration, said they had never heard him use the word "safety." Safety meetings were not essential in this operation. There are many ways to deal effectively with safety training and safe work performance.

No Separation of Production and Health and Safety

There must be no separation of production and safety and health in the management of the mining operations. The best "safety program" is none at all–that is, there is no management activity that is separate and distinct from production management. "Built-in" safety and health should be evident in every work aspect at every level.

Probably the best way to assure that safety and health are integral to all production tasks is to prepare complete written work descriptions, or "safe job procedures," that define the right way to do each task. These are developed through job safety analyses, methods engineering, worker's suggestions, various industrial standards, and equipment manufacturer's recommendations. They are designed to guide the training and supervision of workers. If they are to be effective, these descriptions cannot be mere "read-and-sign" documents designed primarily to "prove" that the worker was trained in case of an accident.

The most important prerequisite for attaining this fundamental condition is that each employee must be provided with precise and comprehensive instructions concerning the proper performance of his or her job, with the instructiions taking into account safety as well as other issues. Assuming that employees accept and follow these instructions, and that management is properly performing its other normal functions (i.e., planning, organizing, and directing), the achievement of this fundamental conditions should require no additional investments.

Honest Commitment to Health and Safety

There must be an honest commitment by the top managers to constantly improve the operation's health and safety performance. This commitment must not only exist, it must be regularly demonstrated. Lippert (*12*) states, ". . . to the extent that the chief executive perceives that 'a safe operation' is important in fulfilling his role, to that extent will safety have importance in the perception of the lower levels of management and supervision." Frequently the safety literature cites the need for the top manager to support the safety department, but such support is not an impressive manifestation of the manager's commitment in the eyes of the workers. The safety department should be devoted to supporting the top manager, who should be leading the way by precept, encouragement and example. With regard to leading by example, Shaw (*13*) writes, "If, on an underground inspection, a manager or supervisor passes an unsafe condition with no comment and then raises cain over production, no amount of later talking about safety is going to convince the workers that he or she is really committed to safety. Therefore, step one in getting safety is the commitment from management."

Several authors have pointed out that failure of upper level managers to effectively demonstrate their commitment to safety, as perceived by the first-level supervisor, will result in the failure of a safety program. Walters (*14*) writes:

> The firstline supervisor tries to do what is requested by his supervisor, but if the secondline supervision and other supervision at higher levels do not act in a manner that supports what they say, then the firstline supervisor soon notes this and governs himself accordingly. As a result, the time and expense devoted to any program is often wasted. In many cases it is the second level of supervision on up that causes the failure of the otherwise successful and well designed policy.

Every manager and supervisor must accept that he or she is perforce the principal safety official for those activities under his or her supervision and that he or she must constantly act in a manner that reflects dedication to proper performance of that responsibility. Representation, direction, and control are the key management functions pertinent to this fundamental condition.

Management Health and Safety Training

Managers and supervisors at all levels must receive basic training in safety and health (more broadly, loss control) management and additional periodic courses to update and upgrade their training in more advanced management techniques. All managers and supervisors must thoroughly understand the costs of occupational illnesses and injuries, and accidents that result in equipment and facility damage. They must be able to correctly relate these costs to productivity and profit losses in the operations for which they have responsibility. A working knowledge of countermeasures to reduce the probability of these losses is necessary, including mastery of simple analyses of cost-to-loss reduction relationship. They must learn to view accidents and job-related illnesses and injuries as failures of management to adequately perform one or more of the management functions. In particular, they must recognize that properly training their subordinates is always a major part of the management functions of direction and control. Many task training needs (identified as part of establishing the first fundamental condition) require careful supervisory planning and innovation. These essential training activities are usually done properly only by managers who are themselves properly trained. However, training, no matter how intensive and thorough, cannot by itself reduce the probability of accidents to acceptable levels. Counter-measure training of managers must include demonstrations and practice in the reduction of workplace safety and health hazards–that is, the technology as well as analyses of alternatives in cost-versus-benefit terms. Management training also must show the manager that the Federal 30 CFR standards and State standards should not consitute a set of management goals, but rather, in general, only a minimum foundation. Finally, the manager must understand that there are some (although few) attractive safety practices or countermeasures that are simply too expensive to implement. There are sometimes advantages in accepting risks–but this will never be true if the degree of risk being accepted is not accurately known.

Management Emphasis on Health and Safety in Organizing and Staffing Functions

Managers must include special emphasis on health and safety in their performance of the organizing and staffing functions. Job-selection processes should include thorough evaluation of employment experience, accident and injury history, physical condition, and learning disabilities and any other handicap. Safety and health risks to handicapped persons and to their employer should be controlled by identifying handicaps accurately and defining training, job assignments, and appropriate performance restrictions accordingly. Periodic performance evaluation (a control activity within the staffing function) must include a loss control

component commensurate with loss control elements that should be included in work descriptions such as those mentioned in the discussion of the first fundamental condition. Employees unable to meet sensible performance standards after corrective retraining, closer supervision, and counseling must be reassigned or discharged. Periodic organizational analysis should be conducted to evaluate the organizational structure and the jobs that comprise it in terms of the current and near-future goals and standards of the mining enterprise. Organization should be dynamic. Like the people in it, it needs correction and redirection from time to time.

Reliable Feedback Mechanisms

There are several reliable feedback mechanisms that have reliable and readily detectable safety and health components. One of the most important of these is the investigation of all accidents and "near misses" using a method designed to identify all factors that may have contributed to the event. ("Accident" is defined as any event that produces an unplanned cost.) Information from such investigations provides management with knowledge about the effectiveness of training, hazard removal, and any other actions that may have been taken to improve safety. It also identifies actions that need to be taken in the future. The "near miss" is an equal, or better, information source than an accident. Palisano (*15*) reports that Exxon Corp. has very successfully used a near-miss investigation program to reduce accidents. The near-miss information is published in newsletters and used to reenact some of the near-misses for video taping instruction material.

Another very valuable feedback or control mechanism is the safety and health inspection. These inspections may be done in many ways. Jones (*16*) reports on a safety audit technique used by Allied Chemical Corp. It measured employee compliance with safety rules; unsafe acts, conditions, and equipment; and the health and safety environment of the plant. The top manager, superintendent, supervisor, and safety officer took part in a twice-monthly audit of the 3,000-employer plant. The audit technique, like the near-miss investigations, provides information about the status of earlier safety and health improvements and the need for new improvement actions.

There are many other feedback methods that produce good results in some mines (job-performance sampling, which is discussed later, is an example), but the two methods discusssed above can be effective in any mining operation – especially if they include the participation of appropriately selected members of the work force. Whatever the methods, they must incorporate accurate records, maintained with care and available for examination by anyone in the workforce. This last fundamental condition is essentially an element of the control function, but it also involves the planning, organizing, staffing, and representation functions.

FIELD EVALUATION PLAN

Gilmore (*8*) notes that ". . . loss control is the art of attaining the optimum balance of loss potential, loss probability and profit." The fundamental conditions discussed in the previous section describe, collectively, the management environment that makes practice of the art of loss control most effective. It would have been desirable, if it had been possible, to evaluate the model health and safety program in terms of objective measurements of loss potential, loss probability, and profit. However, for a variety of reasons, such direct measurements were not possible.

It was decided that the evaluation plan should include considerations such as –

Ease of implementation and administration – A measure of the simplicity, or lack of it, in setting up the program and running it on a continuing basis.

Cost effectiveness – A measure of both the initial installation costs and ongoing costs as compared to the program's effectiveness in reducing accidents and injuries.

Acceptability – A measure of the willingness of labor and management to use the new program.

Compatibility – A measure of how well the program fits into the existing overall mine situation.

Some comments about these considerations will help the reader relate them to the evaluation methods planned for actual use in the field.

It was concluded that there would be no way to measure acceptability except in a subjective way – that is, by using anecdotal data from the mining companies that agreed to allow field implementation and evaluation in their operations. The fact that they agreed indicates **acceptability** by management, and an expectation that the work force would find the model program acceptable too. Although some mining companies declined the invitation to participate in this study, none of them gave as reasons anything that suggested management found the model unacceptable.

The **compatibility** measure, it was decided, would also have to be made from anecdotal data – or perhaps from the lack of such data. Since, as several mining executives noted, the model program dealt with "getting managers to do what they should have been doing all along," it was believed that compatibility would not be a problem except with respect to those managers who might simply resist change – any change.

The **ease of implementation and administration** measurement could be made satisfactorily by compiling a list of recommended actions to implement the model program, discussing them with the top manager and recording his or her decision concerning each action, and observing and rating the progress made over a reasonable period of time. This technique is explained in more detail in the section on program implementation and appendixes A and B.

The **cost effectiveness** measure was more difficult, especially the determination of accident and injury reduction effectiveness. During the field observations, it appeared that only about 5 pct of the mining operations visited recorded and reported accidents and injuries exactly as required by 30 CFR 50. Based on the field observations, it was judged that the mining companies that agreed to participate in the evaluation might not have good records of accidents and injuries (as those terms are defined in 30 CFR 50) and would not have reported as required by 30 CFR 50. In other words, it was anticipated that there would be no suitable baseline data available. (There was a high correlation between good record keeping and correct reporting and the quality of safety and health management. The companies with good records and correct reports probably would not be candidates for participation in the model program, since

they would not see a need for improvement.) It is a part of the last fundamental condition that accurate records be kept of all injuries and **all** accidents, not just those defined in 30 CFR 50, and of near misses as well. If this condition was introduced during program implementation and maintained during evaluation, it was considered very likely that more accidents would be recorded and reported than in the previous year, even if fewer actually occurred. In addition, the probabilistic nature of accidents makes it possible that there could be more accidents in one short period of time than in a second similar period, even though the first period has a lower mean probability of accidents. However, a sustained reduction of the mean probability of accidents (and illnesses) will reduce the long-term accident risk.

One very useful way to judge whether the mean probability of accidents is being reduced is to use a job performance sampling technique. The sampling procedure is a form of inspection. If conducted properly, it not only provides feed back, but also an opportunity for a management person to demonstrate concern for safety and health in a very favorable setting: one-on-one communication at the employee's usual workplace. A job performance sampling procedure was designed expressly for the model program evaluation. Through observation of a randomly selected sample of jobs, the procedure provided a basis for estimating the proportion of the work force that was working with–

Individual job performance deficiencies that could be corrected by the employee alone (P_A), or

Individual job performance deficiencies that could be corrected only through employer action beyond the control of the individual employee (P_B), or

Deficiencies that were common to several jobs of the same kind, or various kinds, and correctable only through substantial changes by the employer in the mining plan, operating policies, or job structuring (P_C).

The sampling process is explained in more detail in the section on implementation and in appendix C.

A second measure related to cost effectiveness is the change in the slope of the cumulative cost of accidents, illnesses, and injuries curve, from the beginning of the program implementation through the evaluation period. Decreases in the slope indicate that losses are costing less. Unfortunately, it was not expected that all loss data would be available at the beginning. It was estimated that several months of training and other management actions would be necessary before all losses could be estimated with reasonable accuracy. However, there is one element of loss data that seemed likely to be available for all the mines from the payroll records: records of work days lost due to work injuries or illnesses. This statistic is certainly not an acceptable surrogate for the total cost of accidents, injuries, and illnesses or even for the total cost of work injuries and illnesses, but it is likely to be a dependable indicator of the trend in those statistics.

A third measure related to cost effectiveness is the "expectation calculation for various health and safety management improvements. It can be used to evaluate the "worth," that is, expected return on investment, of hazard countermeasures, production practice changes, and injury or severity reduction methods. The "expectation" is a representation of the fact that if two or more possible, mutually exclusive events or outcomes can be expressed as numerical values, and each can be assigned a probability of occurrence, the "expected value" of a trial is the sum of the value of each event multiplied by its probability. In short, the "expectation" of the outcome of a chance process is the weighted average of all values of the variable, that is, the arithmetic mean. The "expectation" can be expressed mathematically as follows:

$$E(x) = \sum_{i=1}^{n} x_i \, p_i,$$

where $E(x)$ = expectation,

n = number of outcomes, or "eventualities,"

x_i = cost of eventuality i,

and p_i = probability of eventuality i.

Application of this calculation is explained in the section on program implementation.

PARTICIPATING MINING COMPANIES

Consideration of possible sites for model program implementation and evaluation began during the field research observations (task 2). The following conditions for evaluation mines were established:

Two mine sites should be evaluated, an underground coal mine and mine of a different type in a different part of the country.

The minimum employment at each mine should be approximately 100 persons.

The mines should have significant, but not atypical, safety problems.

There was another condition that took precedence over all of the others: The managements of the candidate mines would have to be willing to participate in the model program evaluation.

Fifteen mines were identified as candidate evaluation sites. These were either mines that were known to members of the research team through work on other projects or mines that were recommended by MSHA mine inspectors who knew about the model program and whose recommendations had been sought by the researchers. From the 15 candidate mines, the researchers chose 8 to be invited and encouraged to become participants in the field evaluation processes. Each of these eight mines received a detailed explanation of the model program and the implementation and evaluation plans. Each also received a formal letter that defined the cooperative arrangement proposed and requested a favorable response. Two mines never responded at all. Two others responded with polite, detailed explanations of their reasons for declining to participate. The reasons had to do mostly with programs of their own, or of their parent companies, which had been recently introduced to improve their health and safety performance. The researchers withdrew the invitation to one mine when they learned of some management problems that appeared to make an agreeable arrangement unlikely. After 2 months,

the total number of mines still considering participation, and being considered by the researchers, had been reduced to three. Finally, agreements were made with two companies, a coal mining company in the East and a metal mining company in the West. They are referred to in this report as company E and company W and are described in the next two sections. The third company was, by mutual understanding, left as a "standby" in the event there were unanticipated serious implementation problems at company E or company W.

MINING COMPANY E

The offices and mines of company E are in eastern Kentucky. The nearest city with emergency medical service and a hospital is Pineville, approximately 15 miles distant.

The company's product is steam coal. The mining operations include both underground and surface mines and, since 1982, a contractor-operated thin-seam miner.

There are two underground mines within a mile or so of the company offices. The newest began production in 1982. Both are "low coal" drift mines using continuous miners and working a seam that has an average thickness of approximately 40 in. There are two surface mining locations (but only one MSHA identification number for both). Mountaintop removal characterizes most of company E's surface mining.

All coal hauling from the mines to the crusher, preparation plant, or holding area is done by a contractor.

Company E operates a preparation plant, a clean coal crusher, and a tipple, at which unit trains, usually of about 70 cars, are loaded for shipment.

The principal production machines in use at the beginning of 1982 are listed below.[5]

<u>Underground</u>

4	Joy 14 CM4-11 AH continuous miners
5	Long Airdox LRB-15A roof bolters
3	Galis 300 roof bolters
1	Wilcox WRDA-5500 roof bolter
4	Joy 21 SC2 shuttle cars
4	Joy 18 SC-7HE shuttle cars
2	NMS rock dusters
6	S and S rock dusters
4	MSA Bantam 400 rock dusters
6	S and S 74SS mine scoops
3	S and S BM-100 mine tractors
7	Kersey BJD mine tractors
2	Rail Runner locomotives
4	Stamler BF-17 feeder breakers
4	Long-Airdox conveyors
10	Kersey 600 CTT supply trailers

[5]Reference to specific products does not imply endorsement by the Bureau of Mines.

<u>Surface</u>

1	Bucyrus-Erie 480W dragline
1	Galion 125 crane
5	Caterpillar D9H tractor-bulldozers
1	Caterpillar D9G tractor-bulldozer
1	Caterpillar D8K tractor-bulldozer
1	Caterpillar D7G tractor-bulldozer
3	Komatsu D355A tractor-bulldozers
2	Komatsu D85E tractor-bulldozers
2	Caterpillar 992B loaders, rubber tired
3	Caterpillar 992C loaders, rubber tired
3	Caterpillar 988B loaders, rubber tired
2	Caterpillar 980B loaders, rubber tired
3	Caterpillar 966C loaders, rubber tired
1	Caterpillar 955 loader, crawler
1	Deere 700A tractor
1	Deere 510 backhoe
1	Caterpillar 637 scraper
1	Caterpillar 16G motor grader
2	Caterpillar 14G motor graders
2	Wabco 85C rock trucks
8	Caterpillar 773 rock trucks
2	Euclid R50 rock trucks
1	Caterpillar 769 water wagon
1	Mack DM685S water wagon
3	Ingersoll Rand T-4 drills
1	Ingersoll ECM 250 Air Trac drill
1	Ingersoll D150 compressor
1	Robbins RR10HD drill
2	Powder trucks
4	ANFO trucks

In 1982, company E's total salable production of coal was nearly 800,000 mt, of which 65 pct was from surface operations. Approximately 12 million mt of overburden was moved.

The organization of company E at the beginning of 1982 is shown in figure 1. In May of 1982, some major organizational changes were made. The principal one, in terms of effect on the model health and safety program, was the creation of an additional level of management: a production manager, a maintenance manager, and a safety and loss control foreman, all reporting directly to the top manager. The new organization is shown in figure 2.

At the beginning of 1982, the total number of company E employees was 362. At the end of the year, the total was 318. The change was due primarily to layoffs in the underground mines as the number of sections was decreased. Average employment was 340. All of the hourly employees, except the security guards, are represented by a union local.

Figure 3 diagrams the major production operations of company E. Not shown are the pond construction and maintenance activities and other pollution controls. Also not shown is the thin-seam miner, which is provided and operated by a second contractor.

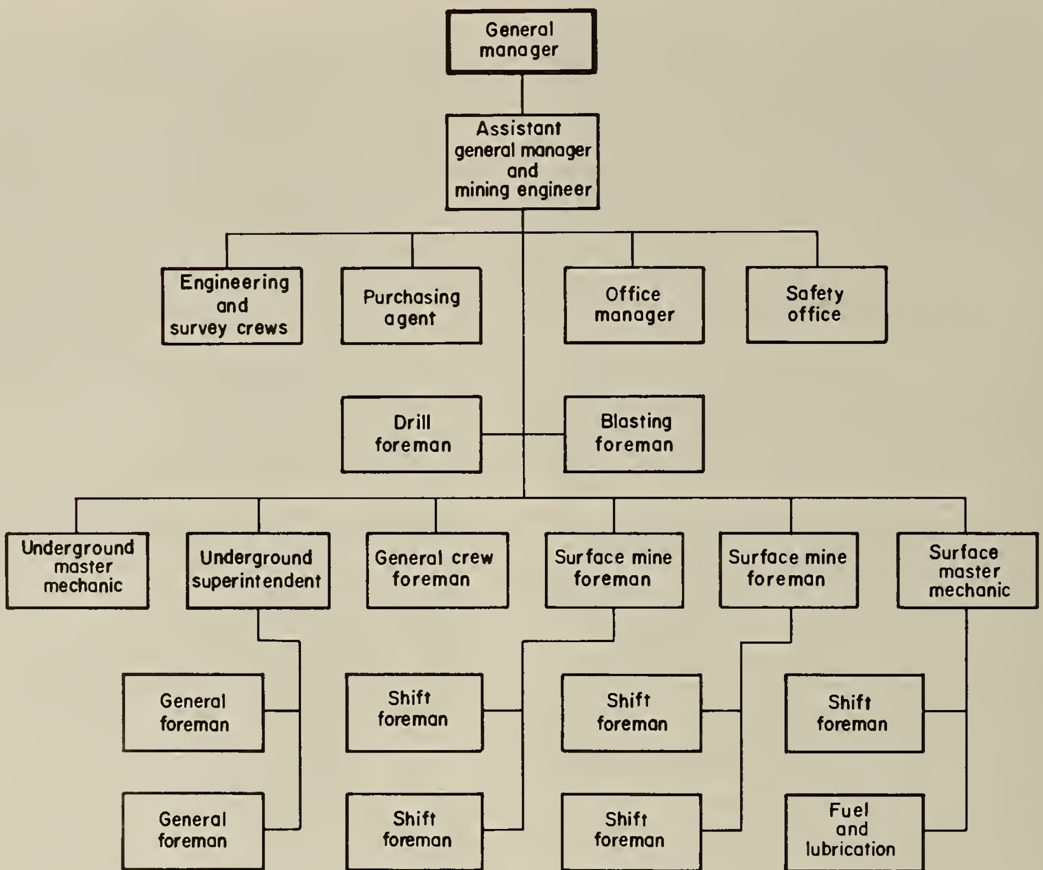

FIGURE 1.—Company E organization, beginning of 1982.

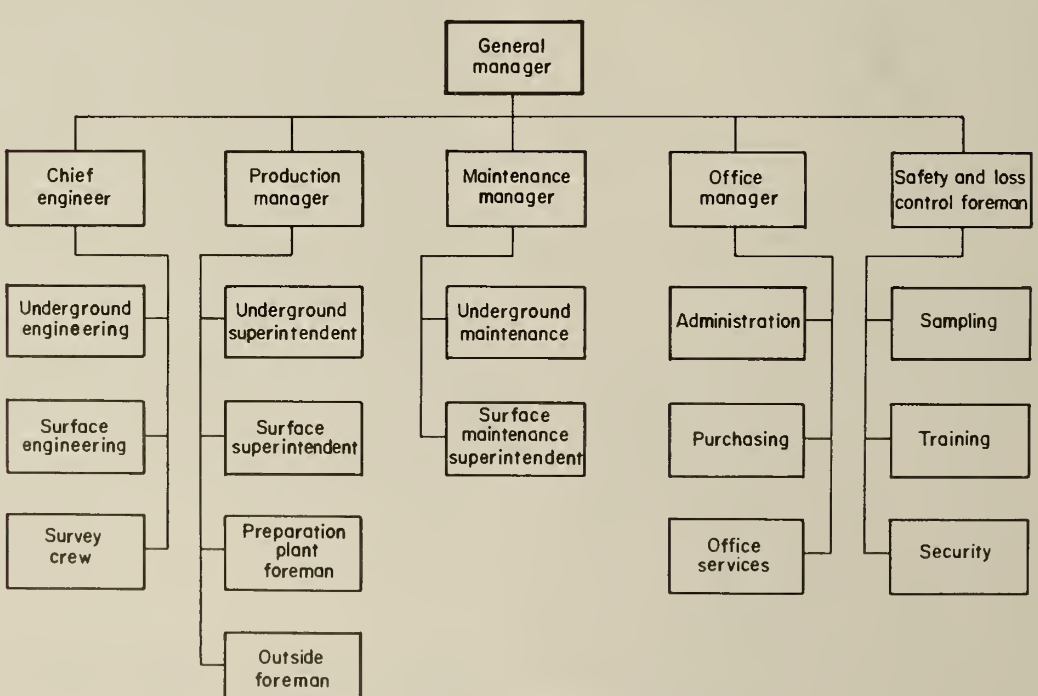

FIGURE 2.—Company E organization, end of 1982.

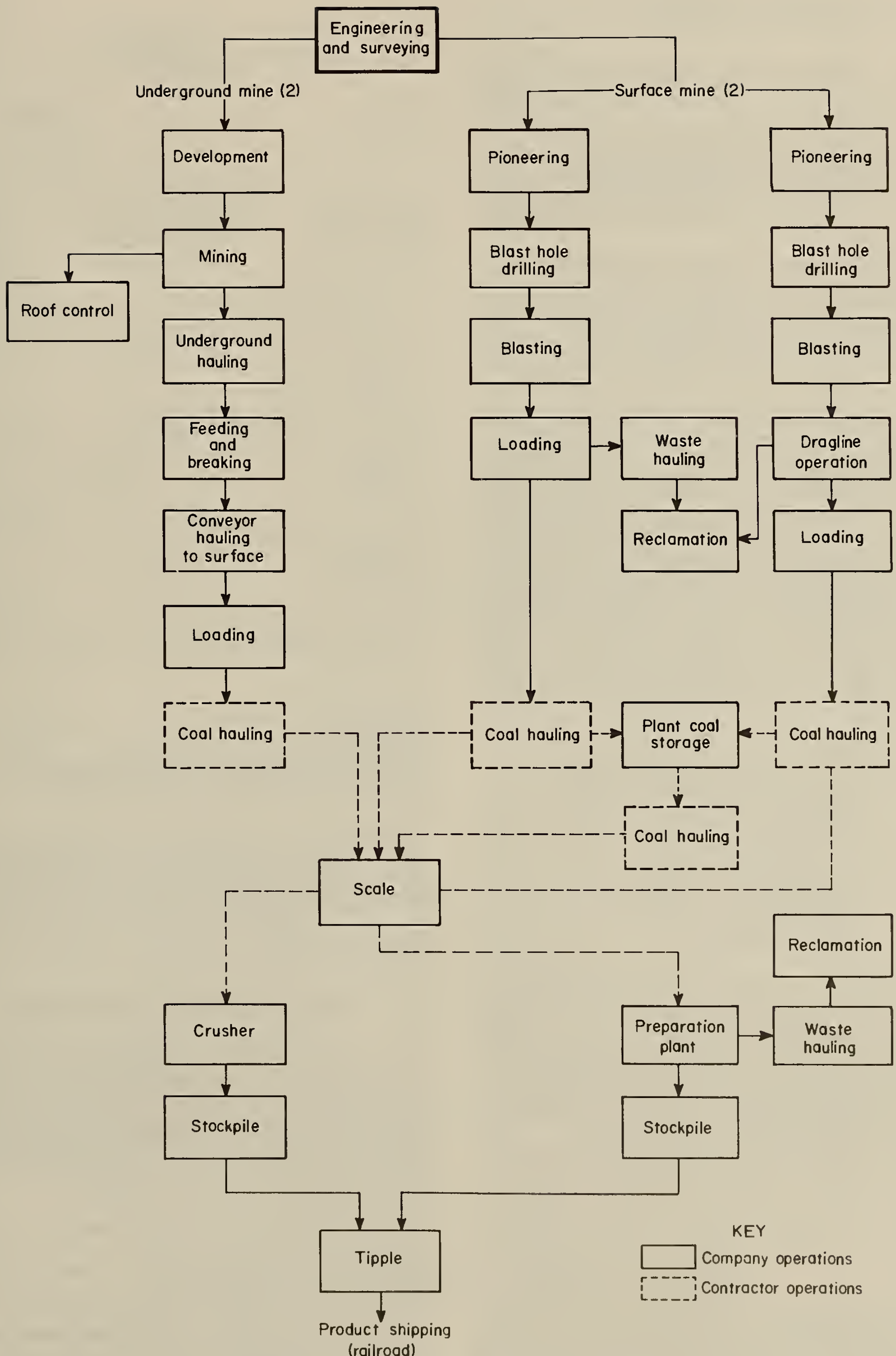

FIGURE 3.—Production operations of company E.

MINING COMPANY W

Located in central Nevada, approximately 210 miles southeast of Reno and 90 miles northeast of Tonopah, NV, company W's product is dore (alloy of gold and silver), poured in bars of 500 to 1,000 oz each. The operation was originally planned to yield approximately 18,000 oz Au and 59,000 oz Ag annually. The ore lies at an elevation of 9,000 ft under 200 to 300 ft of over burden. It assays at only about 0.06 oz/mt Au; thus, the recovery system uses a low-cost, heap-leaching method.

Ore is mined by power shovels and trucked to a crusher at the mine site. There it is reduced to particles of about 0.5 in diam and trucked to a processing area. Crushed ore is piled uniformly on thick plastic sheeting. A dilute cyanide solution is sprinkled on the ore to leach out gold and silver. (Later, spent ore is covered in place with topsoil and seeded with native grasses.) A network of pipe under the ore drains the gold- and-silver-bearing fluid by gravity into a storage pond. From the pond the fluid flows to tanks containing activated charcoal. The charcoal attracts gold and silver particles and removes them from solution. The metals are then stripped from the charcoal by a chemical process. (The charcoal is cleaned and recycled in a closed system.) The metals-bearing solution is fed into an electrolytic cell, where gold and silver adhere to a steel wool electrode. After removal of gold and silver, the solution is returned to the circuit. The gold- and-silver-bearing steel wool is melted, and the impurities are removed. The remaining precious metals are poured into bars and sold to dealers or Government agencies.

The principal mining machines in use in 1982 are listed below.

1	Chicago Pneumatic T650SS drill
1	Gardner-Denver Air Trac drill
2	Caterpillar 245 hydraulic shovels
2	Caterpillar 992B loaders
4	Wabco 50 haul trucks
2	Wabco 50B haul trucks
1	Caterpillar D9H tractor-dozer
1	Caterpillar D8H tractor-dozer
1	Caterpillar 16G grader
1	Wabco 555 grader

Six model 353 Peterbilt tractor and end-dump trailer units haul crushed ore approximately 9 miles from the crusher at the mine to the leach pads near the mill. A Caterpillar D6C dozer is used to construct the leach heaps. Two Fiat-Allis 945 B loaders feed the crushing plant and load crushed ore into the ore trailers. (A contractor supplements the mine's crushed ore hauling capability with five Kenworth tractor and bottom-dump trailer units.)

Although production began in May 1981, the operation was still considered to be in the development phase, and thus 1982 was the first full year of operation. In 1982, this single mine of company W moved approximately 2.203 million mt of overburden and other waste and 0.743 million mt of ore.

The organization of company W at the beginning of 1982 is shown in figure 4. During 1981, the average number of employees was 63; yearend strength was 101. In 1982, the average was 113 and the total varied from 102 to more than 120. There is no union. Organizing efforts in 1981 resulted in a National Labor Relations Board election, but the union was rejected by a margin of more than 2 to 1.

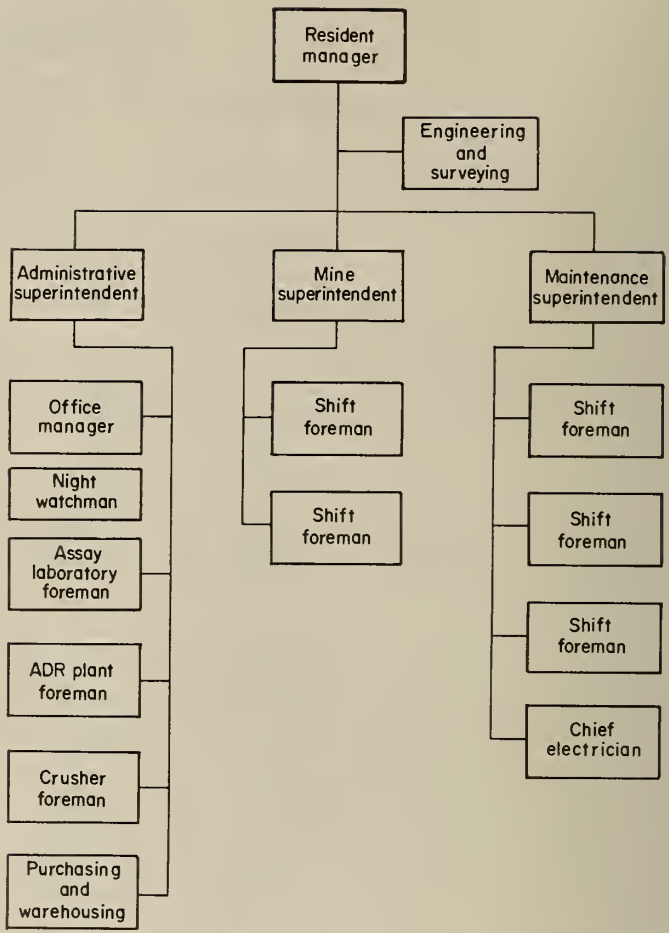

FIGURE 4.—Company W organization, beginning of 1982. (ADR—adsorption, desorption and refining.)

Nearly 65 pct of the company W's employees are in the Mine and Maintenance Departments. (In mid-1982, following the resignation of the maintenance superintendent, the Maintenance Department became a responsibility of the Mine Department. The company's production operations are shown in figure 5.

THE PARTICIPATION AGREEMENTS

The nature of the agreements with the managers who allowed their mines to be evaluation sites has a bearing on the validity of the data obtained. For that reason, the following brief explanations of the agreements and how they were reached are included here. The agreement conditions, as listed at the end of this section, also constitute a description of the model program implementation procedure (which is discussed in detail in the next section.)

The research team had some knowledge of company E from two earlier research projects in which company E's parent company had a role. The safety and training manager of the parent company is an unusually far-sighted safety official who gives a lot of attention to new ideas, methods, and equipment intended to improve productivity and safety. When he heard about the model health and safety program research, he asked for additional information. He then expressed his interest in it and invited the research team to make a presentation on the subject to the top

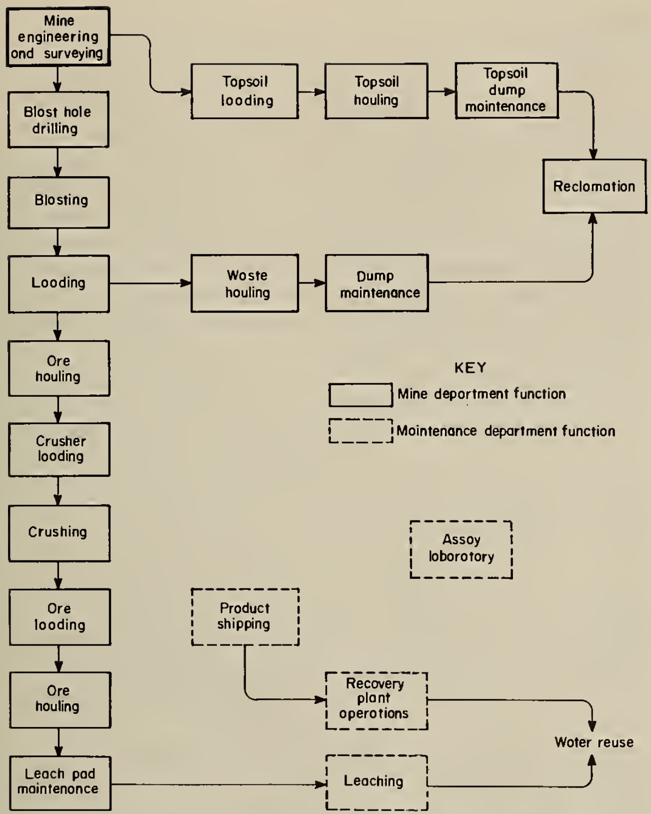

FIGURE 5.—Production operations of company W.

manager of company E. That presentation was made early in 1981, before the model program was defined. The Bureau's objectives were reviewed, and work progress up to that time was discussed. The top manager (the general manager) spoke favorably about the research objectives and agreed to participate in the study. Work at company E began on November 9, 1982, with a safety and health audit of company E's four mines and a job performance sampling.

Company W was known to the research team through some work done for its parent company in February 1981. At that time, company W was just completing construction of its facilities, procuring its equipment, and hiring its initial production work force. Its one mine was in the development phase. In August 1981, the researchers approached the manager of safety of company W's parent company. He was informed of the model program and requested to consider company W as an evaluation site. He expressed much interest and arranged for the researchers to meet with the mine manager and his three subordinate managers, the administrative superintendent, the mine superintendent, and the maintenance superintendent. (Company W had no safety official and has no plans to have one in the near future.)

These managers expressed willingness to participate in the study, and by December a written model program tailored to company W's circumstances and needs had been developed.

The agreements with companies E and W had the same basic conditions:

1. The top company manager (at the mine or mines) stated that he fully understood the fundamental conditions on which the model program was based. He accepted the program as conceptually sound and agreed to put the program into effect in his company.

2. The researchers agreed to complete an initial health and safety audit of the company's operations and, from the information obtained, to define a model program tailored to the company's circumstances and needs. It was agreed that the model program would contain specific recommendations for management action.

3. The top company manager agreed to consider each recommendation carefully and advise the researchers of his decision regarding acceptance. If the decision was to not accept a recommendation, he would inform the researchers of the reason so they could record the information for use in the final evaluation of the program.

4. The researchers agreed to assist the manager in implementing the model program by: (a) training subordinate managers, supervisors, and foremen in loss-control fundamentals using an 8-h course created specifically to prepare supervisory people for implementation of model program concepts; (b) providing 8 h of training to supervisors and workers selected by the top manager in the use of an accident investigation methodology recently developed by the Bureau; (c) furnishing available materials for training mobile equipment operators and assisting in course development, to improve the company's task training; (d) providing health and safety technical literature and other information related to the company's loss-control problems and furnishing advisory service and administrative assistance as desired by the manager, within the scope of the model program; (e) visiting the company's operations once a month for a calendar year, or longer, to assist in program implementation and obtain evaluation data (and the manager agreed to permit the researchers unrestricted access to all elements of the operation for observation and to all available information related to occupational injuries, illnesses, accidents, near misses, and incidents of any other kind that produce loss, that is, unplanned cost; (f) providing the company management periodically with an oral report on observations made, additional management actions recommended, and countermeasure options suggested for consideration, and; (g) at the end of the evaluation period, presenting an oral report covering all of the model program research at the company's operations.

IMPLEMENTATION OF THE MODEL PROGRAM

This section describes how the model program implementation activities were accomplished at the two cooperating mines. The implementation procedure, which had been worked out during the definition of the model program, was designed to be the same at company E and company W. It had several definite, sequential steps. These

were outlined in the previous section ("The Participation Agreements") and are further discussed in the paragraphs below.

Step 1

The top manager has accepted the concepts on which the model program is based. The first step is to prepare for the top manager the information that may be needed to implement the program at his or her operation. This will be done in two ways. First, there will be a safety and health audit of the operation. This audit will not necessarily be comprehensive in every area but it will be sufficiently complete to provide the manager with recommended actions of significance in relation to each of the five previously described fundamental conditions. Pictures to illustrate the discussion of each recommendation should be used whenever possible. The audit report format will be the model health and safety program, tailored to address the specific needs of each operation. Second, there will be an initial job performance sampling at the operation. A sample of 60 to 70 jobs, chosen through a random selection process, without replacement, will be observed for periods of 10 to 20 min each (depending on the nature of the job). Deficiencies in three categories will be recorded in order to calculate the proportion of the sample in which each category of deficiencies exists. The sample proportions will be used as the estimators for the corresponding proportions of all jobs done by the work force.

The first proportion (P_A) will deal with deficiencies the worker could correct without assistance from his employer or from fellow employees. Some examples of these "type A" deficiencies are failure to wear safety shoes, safety hat, or safety glasses or goggles (as required by the specific work); failure to maintain good housekeeping in work area; and loss or damage to property through deliberate actions or carelessness.

The second proportion (P_B) will deal with deficiencies that cannot be corrected by the worker alone. Some examples of the "type B" deficiencies are incorrectly installed seat safety belt, inappropriate tools provided for assigned tasks, and reported machine defects not corrected.

The third proportion (P_C) will deal with environmental, procedural, mining plan, and other general deficiencies which affect several jobs and require management policy action for correction. Examples of the "type C" deficiency are failure to maintain prescribed airflow at the face, poor queuing procedures at a loading point, and failure to maintain necessary area lighting at dump points or congested areas.

From the three sample proportions, a fourth proportion, P_T, will be calculated. P_T is the proportion of jobs in the sample in which at least one of the three types of deficiences could be observed. A mathematical definition of the four proportions is

$$P_A = \frac{n_a}{n}$$

$$P_B = \frac{n_b}{n}$$

$$P_C = \frac{n_c}{n}$$

$$P_T = \frac{n_{(a \text{ or } b \text{ or } c)}}{n}$$

where n = sample size

and n_x = number of jobs with type x deficiency, where x = a, b, or c (corresponding to A, B, and C).

Step 2

The next step is to give the tailored-program report and the job performance sampling results to the top manager and discuss them with him or her. The top manager will be asked to state his or her decision about each recommendation and, for those accepted, to indicate a priority in terms of time to complete the action. The decisions and times to complete each action will be recorded. The top manager will be asked to consider the tailored program as (1) a plan for implementation, to which additions will be made from time to time, and (2) a record of recommendations and decisions made, which the research team will review periodically for program evaluation purposes.

The manager will be asked to explain his or her reasons for any decision not to accept a recommendation so that this information can be recorded for program evaluation purposes. A point value will be assigned to each accepted recommendation (100, 50, or 25). Based on observations of the operation, the research team will periodically assign points indicating the degree to which each recommended change has been made. The top manager will not be informed of the "point system" unless he or she asks specifically how the evaluation is to be done. In that case, he or she will be given an accurate explanation, but the points assigned to each recommended action will not be revealed unless the manager insists. It is very important for the manager to understand that the evaluation methods employed are to evaluate the program, not the top manager. (Neither of the top managers of the two cooperating companies, nor any of the subordinate managers, asked about the evaluation details; no mention was made of the evaluation methods or results until the final oral report.)

Step 3

The research team will provide the training and other assistance desired by the top manager, as reflected by his or her decisions about the tailored program, or as specifically requested. However, it is very important that all assistance provided be in terms of showing people *how* to do things, not doing things for them.

There are certain elements of the researchers' implementing assistance that are of special significance. Perhaps the most important of these is the management training. It is through this training that the concepts on which the model program is based will be explained to the people who must understand them if the program is to be acceptable and effective.

The management training was delivered in four 2-h sessions and addressed the 15 topics listed below.

1. Types of losses in mining. Why some of them are not "counted" and do not receive management attention.
2. The functions and responsibilities of management. How the functions of planning, organizing, staffing, direction, control, innovation, and representation relate to health and safety management.
3. Workmen's compensation and disability costs. How they can be controlled. The "experience modifier" used for rate setting. Self-insurer's cost control.
4. Employee motivation through creating a desirable work situation. Maslow's (*18*) hierarchy of needs. Positive supervisory action.
5. Heinrich's (*19*) "accident pyramid" and how it relates to today's mining industry. The need to examine noninjury

accidents and near misses to determine "preaccident" corrective actions. The near miss as a "harbinger of things to come."

6. Definition of "accident" as any event that produces unplanned cost or loss. Procedures for reporting all accidents and analyses of related events in a fact-finding, rather than fault-finding mode. Accepting the concept that every accident represents some failure in management of the production system.

7. The futility – and risk – of reliance on common sense. The need to define in writing all of management's expectation for each job, and to train and supervise accordingly.

8. Who are the "loss producers"? How are they identified? What should be done about them? Typically, about one-third of the accidents involve only about 5 pct of the workers. Aside from their accident experience, what other factors characterize the 5 pct?

9. The myth that the majority of accidental injuries result from "unsafe acts." The need to reduce or remove hazards in the workplace. Some practical, inexpensive hazard reduction examples.

10. The cost of accidents in company sales terms. How much more product does your company have to sell to pay for a "$500 accident," if the planned profit on operations is to be maintained? Examples to show, for example, "how many extra ore (coal) trucks have to come down the mountain."

11. Evaluating potential countermeasures on the basis of their return on investment (ROI). The logic of investing so long as the ROI exceeds the cost of capital. Countermeasures against accidents, injuries, and inefficient job performance due to poor job design.

12. Analyzing a training problem, using the Mager method of identifying the actual need. How to train for the best results at lower cost. A second look at "task training."

13. Absenteeism and its effects. What the supervisor can do to reduce absenteeism. "Short crew" operating procedures to improve safety and health.

14. The importance of the workers' perception of management's interest in their safety and health, and in loss control generally. How management people, from supervisors to the top manager, must demonstrate their interest, concern, and commitment.

15. Some examples of accidents and near misses, each having many contributing factors. What are the production system management failures? What are the countermeasures? Many countermeasures do not require additional investment.

Because topics 10 and 11 may not be clear from information in earlier sections of this report, the following brief discussion explains them further. Assume that for a certain workplace task there exists a relatively high probability, P_1, of an accident, as evident from the history of accidents over a period of a couple of years. No countermeasure actions have been taken except to explain the accidents to the workers and to tell them to "exercise care." Then several changes are made: Better procedures for doing the task are developed, thorough training is given, and closer supervision is provided.

Typically, each of the first few countermeasure actions (assuming that they are properly planned and implemented) will produce a substantial reduction in the probability of an accident – and at relatively low cost. The return on the countermeasure investment will be readily apparent. The accident probability is reduced to P_2. However, as other countermeasures are applied, the reduction in accident probability may be less and the cost of each countermeasure may be relatively greater (unless there is a substantial technological change in the process design and the character of the task in question is changed very substantially). The actual value of additional countermeasures may not be evident unless a careful analysis is done. Without such analysis, an organization may invest in countermeasures that produce very little accident probability reduction benefit. In other words, P_2 should have become an accepted level of risk. Conversely, without analysis, the organization might not invest in countermeasures that would produce a return significantly greater than the cost. Analyses of countermeasure actions should not consider one hazard alone, but simultaneously all of those extant which are "competing" for countermeasure investment. All organizations have some degree of capital rationing. The logic of "opportunity cost" should be applied in countermeasure action analyses. That is, the choice of a given countermeasure investment must include consideration of other foregone countermeasure investment opportunities that would have yielded a return greater than the cost of capital.

A very simple illustration of one of the several uses of the expectation model as a tool for analysis follows. Table 1, a tabulation of National Safety Council data (*20*), shows the amount of sales in various industries necessary to produce $500 of pretax profit. For the purpose of illustration, assume that a given mine's required sales are somewhere between the amounts shown for "metal mining," $3,335, and "Stone, clay products," $10,870, perhaps $5,000, the amount for "Quarrying mining." Thus, to pay for $45 in unplanned cost (accidental loss), $450 in additional sales will be needed to maintain the planned profit from operations. What may seem to be small risks may actually be quite large in overall profitability terms. To continue the illustration, assume the following:

1. It is estimated that, in a year of operation, there is 1 chance in 20 that a particular accident will occur, based on accident history over several years.

2. If the accident should occur one or more times, the minimum cost (or loss) will be about $5,000.

3. It is estimated that an expenditure of $200 for a given countermeasure would reduce the probability of occurrence of the accident in a year from 1 chance in 20 to 1 in 1,000. Actually, supervisors estimate that the countermeasure will reduce the probability to zero, but 0.001 is taken to be the lowest probability allowed in the analysis.

A simplified expected value calculation is shown in table 2. Two alternative actions are considered. Action A_1 is to take no countermeasure action. The expectation, $E(A_1)$, is that this course of action, give the 0.05 probability of an accident, will cost $250 each year. Action A_2 is to install a countermeasure for $200, and thereby greatly reduce the probability that the accident will occur (to 0.001). If that course of action is taken, the expectation, $E(A_2)$, is that action A_2 will cost $250 per year, or $45 less than action A_1. Again, the $45 represents $450 in sales.

Suppose that, to go further with the illustration, MSHA issues a citation and imposes an assessment of $100 because there is no corrective action for a hazard as required by a 30 CFR standard. For one year at least (the penalty could be increased if the corrective action is not taken), the estimated net cost increases to $5,100 if there is an accident and $100 if there isn't. (See table 2.) The expectation for A_1 becomes $350, and the difference between $E(A_1)$ and $E(A_2)$ becomes

TABLE 1.—Sales needed to offset accident cost[1]

(Sales necessary to produce $500 profit, by industrial group)

Industry	Sales needed
Aerospace	$16,665
Air transport	16,655
Amusements	7,815
Autos, trucks	11,365
Automotive parts	11,905
Baking	17,855
Brewing	10,870
Building, heating, plumbing equipment	12,195
Cement	9,260
Chemical products	7,575
Clothing, apparel	13,515
Common carrier trucking	13,890
Construction	11,630
Dairy products	16,130
Department, specialty stores	16,130
Distilling	9,805
Drugs, medicines	5,050
Electrical equipment, electronics	10,205
Electric power, gas	5,050
Farm, construction-materials handling equipment	8,195
Food chains	50,000
Food products	12,195
Furniture, fixtures	13,515
Glass products	7,935
Hardware, tools	9,615
Household appliances	10,640
Instruments, photo goods	6,755
Iron, steel	14,285
Lumber, wood products	8,185
Machinery	9,435
Mail order business	10,870
Meat packing	33,335
Metal mining	3,335
Metal products	13,160
Nonferrous metals	10,635
Office equipment, computers	5,495
Paint, allied products	20,000
Paper, allied products	8,335
Petroleum products, refining	9,615
Printing, publishing	8,065
Quarrying, mining	5,000
Railroads	33,335
Restaurants, hotels	11,365
Rubber, allied products	20,835
Shoes, leather goods	12,820
Soap, cosmetics	7,245
Soft drinks	7,145
Stone, clay products	10,870
Sugar	17,855
Telephone, telegraph	4,715
Textile products	17,855
Tobacco products	9,615
Variety store chains	16,665
Wholesale houses	20,000

[1]Dollar value of goods and services required to produce $500 pretax profit. Profit margins are the most recent published by Citibank of New York for leading corporations reporting sales or gross income figures.

Source: National Safety Council.

TABLE 2.—Simplified expected value calculation

Eventuality	Probability of occurrence	Annual net cost: Normal	Annual net cost: With penalty
Action A_1 (no corrective action):			
Accidents occur	0.05	$5,000	$5,100
No accidents occur	.95	0	100
$E(A_1)$[1]	NAp	250	350
Action A_2 (corrective action):			
Accidents occur	.001	5,200	NAp
No accidents occur	.999	200	NAp
$E(A_2)$[1]	NAp	205	NAp

NAp Not applicable.

[1]Expectation, E(A) = (Probability of occurrence) (annual net cost) for situation where accidents occur plus (probability of occurrence) (annual net cost) for situation where no accidents occur.

$145, or $1,450 in sales. Generally, the cost of an MSHA assessment is but a fraction of the cost of an accident. This is often true even if the internal costs of discussing, disputing, and protesting an assessment are added, although these kinds of internal costs may subtantially increase $E(A_1)$.

The research team also provided training in accident investigation methods. Further information about this training can be found in the final report for a prior Bureau contract (*17*).

MINING COMPANY E

Work to implement the model program at Company E began in November 1981 with (1) a health and safety audit that would later be the basis for the tailored program and (2) the initial job performance sampling. The job performance sampling produced the following results:

P_A = 0.676. The most frequent deficiency was failure to wear prescribed personal protection equipment, especially safety hats. Several supervisors were among those who did not wear safety hats. Many haul trucks had unauthorized reading material and other "extraneous materials" in the cab, in violation of 30 CFR 77.1607(d).

P_B = 0.284. The most frequently deficiency was the absence of or incorrect installation of seat safety belts in mobile machines.

P_C = 0.257. The most frequent deficiency was very poor area housekeeping. There were inadequate berms along some haul roads.

P_T = 0.743. Of the jobs sampled, 74.3 pct were being performed with one or more of the three types of deficiency.

In March, the top manager notified the research team that all the recommendations contained in the tailored model had been accepted and that implementation of the program was to be coordinated by the company's safety officer.

In April, the top manager was discharged for reasons that had nothing directly to do with the model program. The new top manager was a mining engineer with several years of experience as the mine manager at a large underground coal mine in a nearby State. The pace of the model program implementation increased immediately following his arrival – especially the training and workplace hazard removal activity. He set an excellent example for other supervisors and workers. However, progress in a few areas was slow, particularly in the use of personal protection equipment. The reason had to do primarily with the top manager's desire to avoid actions that might cause "labor trouble" at company E. The manager said he agreed with the model program recommendations and intended to put them into effect, but he preferred to do so with the full approval – perhaps even at the initiative – of the union local officials and some of the senior supervisors who were forecasting "trouble" if changes were made too rapidly. This process would "take some time," he said. He was correct. Some of the personal protection equipment rules would not have become effective as soon as they did had the parent company (new owner) not ordered them at all of its properties. To demonstrate the parent company's commitment

persuasively, two vice-president-level officials visited Company E several times and during each visit made clear to managers and workers that safety and health were matters of great concern and high priority. By the time this happened, the new top manager of Company E had, through discussion, example, and considerate suggestion, developed an atmosphere of acceptance and cooperation.

The implementation assistance provided by the research team included training nearly every month through January 1983. The courses for managers were given to groups of three to eight, usually for 4 h during one month and 4 h during the next. Thirty-one managers completed the "Introduction to Loss Control Management" course, and 32 completed the "Accident Investigation Methods" course. Other implementation assistance by the researchers included–

Assisting the safety official (designated "Safety and Loss Control Foreman" in April 1982) in setting up an improved accident reporting and records system.

Acquiring sets of climbing lines (webbing with carabiners on each end) for use by persons who must climb drill masts and demonstrating the use of the equipment to the safety and loss control foreman, drill foreman, surface superintendent, and drill workers.

Assisting the safety and loss control foreman and maintenance superintendent in acquiring expanded metal ladder treads, and constructing from them and used conveyor belting lower suspended steps (two or three steps) for haul truck ladders and ladders of other large surface machines; and setting up evaluation of the step units with driver participation.

Assisting the safety and loss control foreman to plan, prepare, and narrate two audio-visual hazard training programs, one for surface mine visitors and new employees and one for underground mine visitors and new employees.

Coaching selected shift foremen and the safety and loss control foreman through approximately 20 accident and near miss investigations, using the method taught in the accident investigation course.

Instructing the safety and loss control foreman and three other people in operation of the Terex 33-11C (85-mt) haul truck, using training materials and simulator equipment developed under a prior Bureau contract (*21*); and coaching these people in the use of the materials and the simulator to train others.

Assisting underground mine superintendents in planning and implementing "absentee controls."

Providing for trial by roof bolter machine operators a new type of safety glasses which provides better eye protection with less interference with, or distortion of, vision.

Coaching the safety and loss control foreman and two other persons in use of the job performance sampling method used for evaluation (following a company decision to use the method in the regular monthly mine inspections).

Providing the safety and loss control foreman with a large number (30 or more) of technical references to answer questions he asked and provide authoritative sources of information for training materials he prepared.

Discussing with superintendents; shift, section, and job foremen; the wash plant foreman; the tipple foreman; and the "deadwork" foremen problems in training, supervision, and hazard removal, and other loss-control areas they identified and asked to discuss.

Assisting, as requested, in completing actions necessary to implement the recommendations in the tailored program.

Appendix A of this report contains some excerpts from the tailored program document for mining company E, which was based on the health and safety audit of November 1981. The excerpts will enable the reader to see the form and content of typical recommendations. The management decision and priority (which in the case of company E, was usually set by the safety and loss control foreman) are given. The points assigned by the research team are also listed, although, as mentioned earlier, these were not known to management.

MINING COMPANY W

The health and safety audit for company W, the basis for the tailored program, was performed in October 1981. The initial job performance sampling was also done at that time. Sixty-six jobs were included in the sample. The results were as follows:

P_A = 0.818. The most frequent deficiences were failures to wear safety hats, safety shoes, and other prescribed personal protection equipment; and poor housekeeping in mobile machine cabs.

P_B = 0.409. The most frequent deficiencies were lack of seat safety belts in mobile machines, inoperative backup alarms, and inadequate hearing protection in high-noise areas (crushing plant).

P_C = 0.591. The most frequent deficiencies were poor area housekeeping and assignment of inappropriate machines to some tasks.

P_T = 0.864. Of the jobs sampled, 86.4 pct were affected by one or more of the three types of job performance deficiences.

The safety and health audit, the "tailored program," and the job sampling results were discussed with the top manager (resident manager) in December. He accepted the majority of the recommendations for implementation and requested that the courses in loss control management and accident investigation methods begin immediately.

The manager preferred that each course be limited to 2 h per month. Thus, 4 months passed before the management course was completed by the resident manager and the other five managers (superintendents and mine shift foremen). The accident investigation course was completed by nine people: the resident manager, the three superintendents, and five workers (elected from the five major work groups to serve as members of a labor-management committee).

The pace of the initial implementation work was aided by two fortuitous events not anticipated by the research team. These events were fortuitous in that they noticeably increased management's interest in, and concern about, the consequences of safety and health deficiencies. The first of the events was a safety inspection by company W's parent company safety staff. It reported 70 deficiencies, both large and small. The report came "through channels," with directives for action, many of which were the same ones recommended in the researchers' tailored model. The second event was that an MSHA mine inspector gave advisory compliance notices to management concerning many of the deficiencies that were also in the parent company's report and the model program recommendations, and some which were not. His work was especially helpful in calling attention to some air contamination problems in the mill. He was very

helpful, and also very firm, in his recommendations to company management.

There was no safety position (this is, no safety official) at company W and no intention to create one. Thus, unlike company E, where much of the research team's implementation assistance came from the safety official, implementation at company W was directed primarily by the three superintendents. (See figure 4). In addition to conditions addressed in the specific recommendations of the tailored program (excerpts from which are given in appendix B), there were several unsafe conditions in the operations for which each superintendent was responsible. Some of these were identified in the MSHA and parent company reports. Some were not. The research team believed it would be appropriate to address all unsafe conditions aggressively as part of management training. This belief was strengthened by the defensive reactions of two of the three supervisors during some "walkarounds" to point out the hazards. Some of the common reaction were as follows:

"No one has ever been hurt."
"If a worker gets hurt, it'll be caused by human error."
"It hasn't been cited by MSHA."

The general approach used to "coach" the managers through eliminating or reducing unsafe conditions is indicated in figure 6. The two actions shown closest to the box labeled "Unsafe conditions" in figure 6 could be taken immediately. Usually the needed personal protection equipment was on the property or could be obtained within a day to two. Closer supervision usually amounted to instructing foremen about the hazard and precautions that could be taken, in addition to requiring use of personal protection equipment. Prohibiting a worker from doing a task alone was a frequent countermeasure. Establishing sound work procedures is best accomplished through participation of workers as well as supervisors, and reference to industrial standards and practice documents. As indicated in figure 6, employees must be trained in the new procedures. Establishing procedures takes time, typically 2 to 4 weeks. Removing unsafe conditions is the most effective way to reduce risk, but may require the most time to complete and some additional investment. Suggestions from workers who perform the task are often of great value in defining alternatives. Removing the unsafe condition must be the management goal; however attaining that goal is not always possible. On the other hand, it is often possible to accomplish this goal with surprising ease, once management reluctance to take action has been overcome. This is the principal lesson of the special training for the superintendents.

A second area that required special training emphasis at company W was compliance with 30 CFR 50. It is not 30 CFR 50 recording and reporting per se that is important, but the entire subject of accurate accident, injury, and near-miss records. It was found at the beginning of the model program that not one of the superintendents or foremen understood the 30 CFR 50 requirements accurately. As at the majority of the mines visited during the background research, the decision about what to report on the MSHA form 7000-1 (mine accident, injury, and illness report) was left to a clerical person who did not understand the 30 CFR 50 requirements either. Furthermore, the clerk could report to MSHA only what was recorded by the supervisors, that is to say, very little. The research team's first training attempt produced very unimpressive results. When tested, the

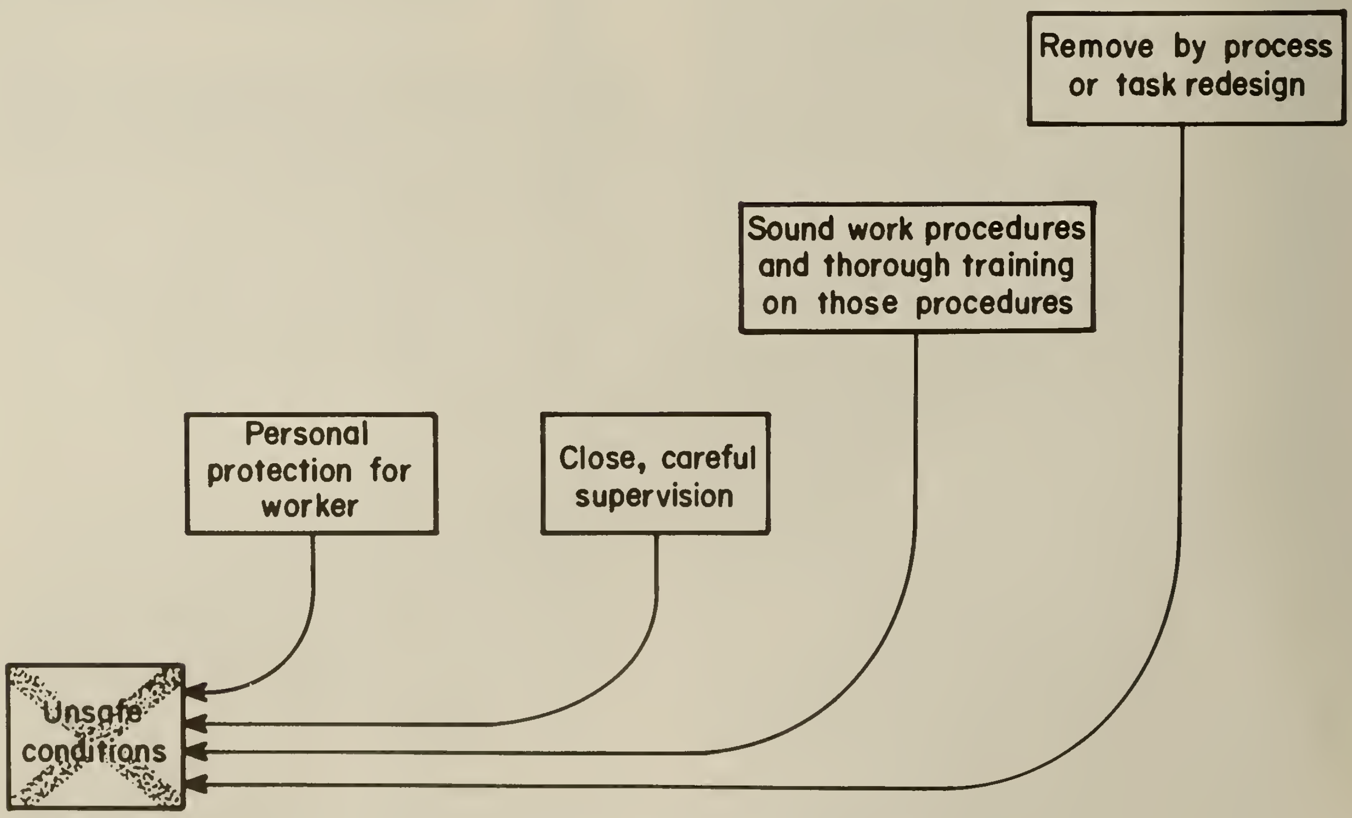

FIGURE 6.—Approach used to reduce unsafe conditions.

supervisor's understanding of 30 CFR 50 was shown to be very little better after the training than before. It was clear that the training method needed improvement. The problem of getting people to understand the rules was discussed one day with some MSHA mine inspectors. One of them has a "flow diagram" that depicted the rules for investigating and reporting injuries (but not accidents). The research team took his idea and expanded it to create a guide. The guide and about 30 "example cases" were used in subsequent training with good results at company W. (Similar results were produced with the same training later at company E).

Other implementation assistance activities of the research team at company W included–

Obtaining technical information from MSHA and instrument manufacturers about methods of sampling the plant air for mercury vapor content.

Assisting the maintenance superintendent in evaluateing several types of available jib and gantry cranes for use in a maintenance shop bay that had no bridge crane installed. (The shop was using a front-end loader or a forklift truck to lift engines and transmissions out of machines in a manner that was both hazardous and expensive.)

Acquiring for the mine superintendent a copy of a Power Shovel and Crane Association manual titled "Hydraulic Excavators and Telescoping Boom Cranes" and assisting him in instructing workers who would become authorized operators of two truck-mounted cranes.

Making copies of 29 CFR 1910.184, which deals with slings on truck-mounted cranes for the maintenance superintendent; giving instruction and conducting demonstrations for selected mechanics on the correct ways to rig loads for crane lifts, based on the 29 CFR 1910 standards.

Preparing, at the request of the mine superintendent, a reference book containing the manufacturers' operating manuals for every type of mobile machine used at the mine. (There had been no operating manuals at the mine.)

Preparing a haul truck operator training guide for instructors who trained new employees on Wabco 50 and 50B trucks.

Preparing a hazard training program, using slides and audio tape, for visitor and employment applicants.

Arranging for training films to be loaned to company W for showing at safety meetings.

Contacting another mine (a mercury mine), at the suggestion of MSHA, to obtain for company W some user's experience information regarding air monitoring instrumentation.

Providing a copy of a slide and audio tape training program on preshift inspection of off-highway diesel trucks developed under a prior Bureau contract (*22*).

Preparing, for the drilling and blasting foreman, a task training guide for new employees assigned to drill or blasting crews (based on 30 CFR 55 standards; U.S. Army Corps of Engineers general safety requirements as listed in section 25 of reference 23; and the "Excavation Handbook," by Horace K. Church (*24*)).

Participating in the monthly meetings of the management-employee committee (at the invitation of the resident manager).

Conferring with individual workers, as requested by the resident manager or a superintendent, to encourage their acceptance of new safety rules (for example about using safety seat belts in bulldozers, about dust masks and ear protection in the crushing facility, or about forced ventilation in confined areas when welding).

FIELD EVALUATION OF THE MODEL PROGRAM

This section discusses the field evaluation, the final research task in this project. Following the initial job performance sampling at both of the participating mining companies, the research team made some estimates about how the companies compared to others in the mining industry and the degree of improvement that could be attained through implementation of the model program. The estimates were based on trial experiences with the job performance sampling technique and some subjective observations at 60 operations, including those visited during the background research phase of this project. It was judged that the 60 were a reasonably representative sample of the industry, at least for the purpose of the desired estimates.

"Loss control management effectiveness" is used rather than "health and safety management effectiveness" because the sampling nearly always included some things usually not considered to be health and safety matters. Loss control management effectiveness is inversely proportional to the amount of loss risk tolerated in an operation. The samples taken in the 60 operations suggest that if mining operations were placed in an array according to degree of loss risk acceptance and the distribution plotted, the resulting graph would be approximately a normal distribution with large variance, that is, one with a characteristic shape like that shown in figure 7. In figure 7 approximately 68 pct of all operations in the distribution are included within ± 1 standard deviation ($\pm 1\sigma$) from the mean, and 95.5 pct are within $\pm 2\sigma$. The various levels of risk may be defined as follows (from right to left in the graph in figure 7):

"Very high loss risk": Operations judged to have an overall loss risk that is more than 2σ above the mean. Very poor loss control management. Approximately 2.3 pct of all operations will be in this group.

"Well above average loss risk": Operations judged to have an overall loss risk that is more than 1σ above the mean, but less than 2σ. Poor loss control management. Approximately 13.6 pct of all operations will be in this group.

"Above average loss risk": Operations with overall loss risk above the mean, but less the 1σ above it. Below average

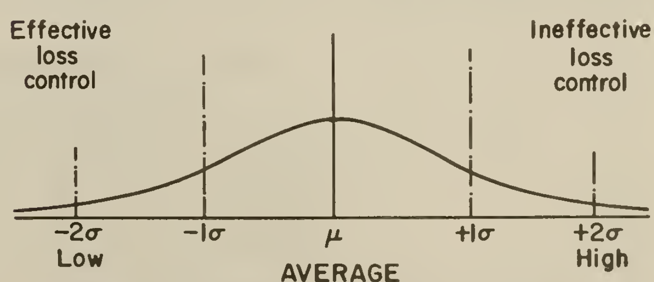

FIGURE 7.—Distribution of loss control management effectiveness.

loss control management. Approximately 34.1 pct of all operations will be in this group.

"Below average loss risk": Operations with overall loss risk below the mean, but less than 1σ below it. Above average loss control management. Approximately 34.1 pct of all operations will be in this group.

"Well below average loss risk": Operations with overall loss risk more than 1σ below the mean, but less than 2σ below it. Excellent loss control management. Approximately 13.6 pct of all operations will be in this group.

"Very low loss risk": Operations with overall loss risk more than 2σ below the mean. Outstanding loss control management. Approximately 2.3 pct of all operations will be in this group.

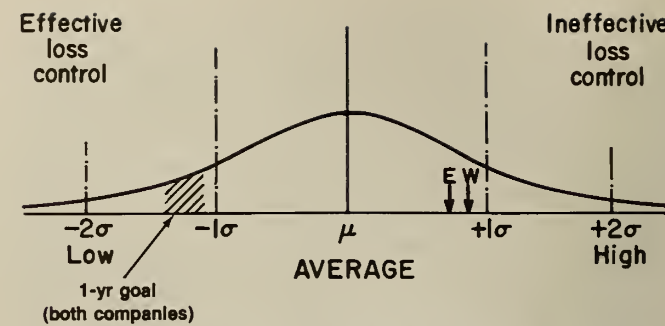

FIGURE 8.—Loss control effectiveness positions of companies E and W.

Figure 8 shows the estimated positions of companies E and W in the distribution prior to model program implementation. The estimate was that their loss risk positions were better than those of approximately 20 to 25 pct of the mining operations. They had above average loss risk and below average loss control management.

A realistic goal of 1 yr of serious implementation of the model program, the research team estimated, would be to improve loss control management so that a followup evaluation made in the same way would put the companies in the top 10 to 15 pct of the distribution. Their loss risk positions would then be "well below average," indicating excellent loss control management. The shaded area in figure 8 graph, to the left of -1σ, indicates the region they would occupy in the distribution. Another way of stating the same "goal" is to say that the job performance sampling results would show

$$P_A \leq 0.05,$$
$$P_B \leq .05,$$
$$P_C \leq .05,$$
and
$$P_T \leq .05.$$

The research team judged that a P_T of 0.05 or less would surely place a mine in the top 10 to 15 pct of the distribution of loss control management effectiveness ratings. Not one of the 60 operations at which the job performance sampling technique was tried had a P_T value as low as 0.05, but one of them came close. The P_T values corresponding to the distribution "tail," beyond -1σ, were not at all clear. It may be that a P_T value of 0.05 corresponds to -2σ, that is, the top 2.3 pct of operations in terms of loss control management effectiveness. In any case, there seemed to be no reason to think that a $P_T \leq 0.05$ could not be achieved, provided that the model program was implemented effectively. It was judged that "effective implementation" would be the attainment of a total score of 80 pct or more of the points assigned to the recommendations in the tailored program accepted by management.

As previously stated, none of the managers knew anything about the evaluation method except that they were told the values of the four proportions from the initial sampling and the deficiencies that were observed. The research team did not want the managers to concern themselves with "scorekeeping," lest they get into a "contest frame of mind." Had that happened, the fifth criterion for the model (acceptability on its merit alone) probably could not have been evaluated.

MINING COMPANY E

The results for the five job performance samples taken at company E are given in table 3 and shown on the graph in figure 9. Note that the high initial P_T (0.743) was mostly due to the high P_A (0.676). Company E had poor employee performance with respect to personal protection equipment, partly because the local rules were merely restatements of MSHA standards and partly because little had been done to encourage compliance with the rules. The substantial change in P_A between March 1982 and January 1983 was due primarily to improved workplace housekeeping; machine operators keeping cabs, windows, and mirrors clean and observing speed limits; welders wearing proper protective gear more frequently; and more underground miners using eye protection.

The change would have been much greater except that the top manager did not believe that two new personal protection rules could be uncompromisingly enforced during the period without difficult problems involving the union and some supervisors. Near the end of the period, directives from company E's parent company made the two rules mandatory at all of the parent company's operations. These rules required (1) the wearing of safety helmets ("hard hats") by all persons on the property except office workers while in their offices and (2) the wearing of seat safety belts by operators and authorized passengers in all mobile mining machines and personnel vehicles. These rather fundamental safety rules had been operative only to the extent that the

TABLE 3—Job performance sampling results, company E

Month	Sample size (n)	Proportion of jobs with deficiencies, by type[1]							
		P_A		P_B		P_C		P_T	
		n_a	Factor	n_b	Factor	n_c	Factor	n_t	Factor
November 1981	74	50	0.676	21	0.284	19	0.257	55	0.743
March 1982	76	51	.671	24	.316	19	.250	56	.737
June 1982	64	39	.609	20	.313	14	.219	44	.688
September 1982	70	35	.500	20	.286	14	.200	39	.557
January 1983	52	16	.308	13	.250	9	.173	19	.366

[1] $P_A = \frac{n_a}{n}$ $P_B = \frac{n_b}{n}$ $P_C = \frac{n_c}{n}$ $P_T = \frac{n_{(a\ or\ b\ or\ c)}}{n}$

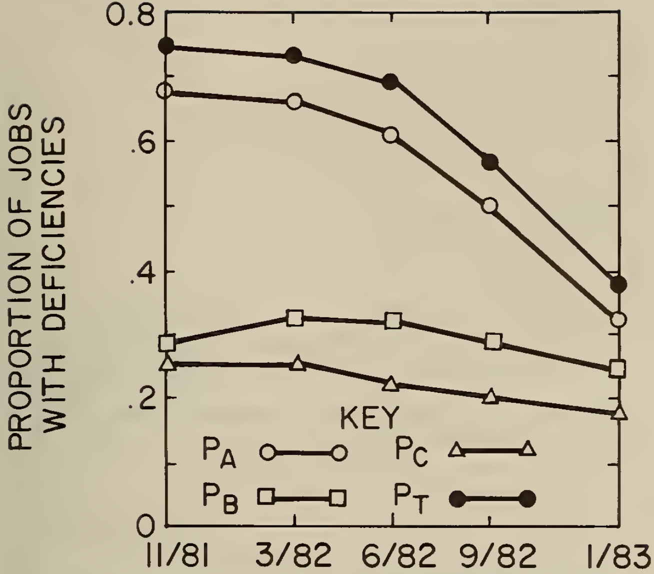

FIGURE 9.—Proportions of jobs sampled at company E in which deficiency types P_A, P_B, P_C, and P_T were observed.

safety and loss control foreman and other cooperating foremen had been able to influence workers through example, training, and persuasive discussion. Had the rules been established and enforced in say, September 1982, the January P_A would likely have been approximately 0.190, rather than 0.308. This statement is made with some confidence because the research project manager had the opportunity to visit company E in late March 1983 in connection with another project, and a job performance sampling done at that time showed a decrease of nearly 0.120 in P_A since January 1983. (The sampling also showed decreases of approximately 0.07 in P_B and 0.05 in P_C.)

The small decreases in P_B and P_C between March 1982 and January 1983 indicate, as noted earlier, a relatively slow start in correcting deficiencies of types B and C and a longer time to complete implementation than was originally estimated. The degree to which management was able to put into practice the recommendations in the tailored model may also be reflected in the relatively low rate of decrease in P_B and P_C. (These recommendations are listed and discussed later in this section.) The increase in P_B from November 1981 to March 1982 was very likely due primarily to unusually harsh weather in January and February. For several weeks it took all of the available maintenance capability do the work necessary to keep the surface machines moving so that surface production could be sustained. There was no time available for what was regarded as "nonessential" work. In other words, the management felt it was necessary to accept an extra short-term risk in order to satisfy contractual commitments and keep coal moving to the customers.

The discussion in this section has been about sample proportions. P_T is the proportion of the sample in which some job performance deficiency was observed. In the population of all jobs in company E, the job performance deficiency proportion is termed Π_T. The best estimator of Π_T is P_T. The population proportion is made with certain confidence limits. Figure 10 shows the 95-pct confidence limits for each estimate of π_T, where the π_T curve was plotted from the P_T values shown in figure 9. (The scales of the ordinated and abscissa were changed to make the confidence intervals easier to visualize.)

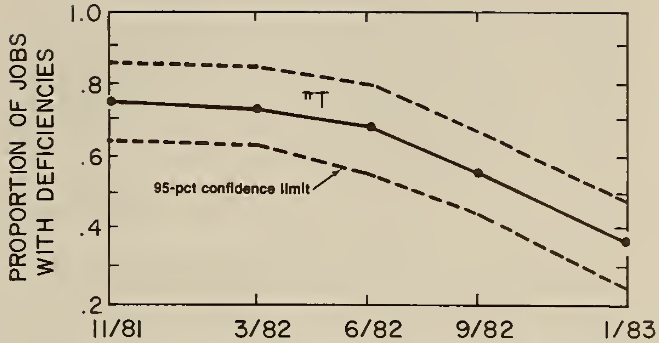

FIGURE 10.—Job-deficiency 95-pct confidence limits for π_T at company E.

Table 4 is a list of the recommendations that were included in the tailored model for company E. The points assigned to each recommendation by the research team (for

TABLE 4.—Recommendations in tailored model for company E

Recommendations	Assigned points[1]	Attained points
Train and stress loss control management	100	75
Integrate safety and production in each job definition	100	25
Identify job for full-time safety person, if desired	100	95
Improve visitor control and training	100	90
Stop practice of loading private coal in pit	100	100
Better housekeeping:		
Plant	50	40
Surface shops	50	10
Underground shops	50	40
Surface mine	50	25
Proper parking of private vehicles	50	30
Get extraneous materials out of machine cabs	50	40
Correct safety guide re: ROPS and seat belts	50	15
Stop welding, drilling, or cutting ROPS	50	30
Institute end-of-shift inspection requirements	50	40
Keep windows and mirrors clean	50	30
Improve hopper closing on railroad cars	50	0
Check "panic bar" operation daily (on roof bolters, shuttle cars, and continuous miners)	100	90
Make certain adequate fire extinguishers are provided and serviced	100	90
Secure all blasting material at end of shift	100	85
Top managers to—		
Set example	100	75
Budget safety time	100	20
Review investigations	100	50
Observe and give reinforcement	100	50
Require near-miss investigation and discussions	100	50
Improve ladders on mobile machines	100	10
Correctly install and maintain seat safety belts	100	90
Require all workers and supervisors to wear safety hats, except in offices	100	70
Establish and enforce a clear, safe personal radio policy for mobile machine operators	50	25
Establish and enforce road-width and berm-dimension policy	100	50
Remove hazards noted at tipple	100	75
Create requirement for noninjury accident reporting	100	80
Create safety committee that includes workers	100	60
Create emergency responsibility plan for weekends and holidays	100	75
Provide guard at surface mine with land line or radio communication with main gate	50	0
Improve method of providing and servicing personal safety equipment	50	0
Improve recordkeeping and reporting	100	80
Improve task training	100	80

[1]Points assigned by research team as basis for evaluations.

evaluation purposes) and the points attained during the implementation and evaluation periods are also shown. The maximum attainable score was 3,000. As noted earlier, the research team had judged that attainment of 80 pct of the points, or 2,400, would represent effective program implementation. The actual attainment by company E was 1,890, or 63 pct of the total assigned points.

Most of the recommendations in table 4, although stated in very brief form, are self-explanatory. A few require additional explanation.

"Correct safety guide re: ROPS and seat belts" referred to rules in Company E's safety rule book. The rules were: "Vehicles driven with doors open must have the operator secured with seat belts," and "Roll bars (ROPS) and canopies must be provided on equipment such as front-end loaders and bulldozers for the operator's protection in the event of capsize."
The recommendation was to make clear to workers, through training and supervision, (1) that the seat safety belt must be worn in every vehicle any time it is operated, (2) that the use of the seat belt is essential to protect the operator in mobile equipment equiped with ROPS, and (3) that 30 CFR 77.403a requires the use of seat belts on ROPS-equipped mobile equipment. The recommendation also called for incorporating the seat safety belt rules into every work procedure involving vehicles on mobile equipment and modifying the safety rule book appropriately if management wished to continue its publication.

"Create safety committee that includes workers" referred to a need to encourage cooperative effort on safety and health matters. The union contract had a provision for action by an elected safety committee in the event that serious safety hazards were allowed to occur in a mine. There was a company safety committee that consisted entirely of management people. There was more than a hint of hostility in the operation of the union safety committee, and the company committee's mode of operation seemed to do little to encourage the adversaries to become cooperating participants in the processes of hazard identification and removal. These are management processes, but they are done best when the ideas of the workers are solicited and considered. Some of the other recommendations are explained by the examples in appendix A.

Figure 11 shows the number of injuries and work-related illnesses at company E in each month of 1982 that was required to be reported to MSHA under 30 CFR 50 provisions. Accident, injury, and illness recordkeeping and reporting improved greatly during this period (program implementation and evaluation). However, the number of "reportables" per month had a small downward trend during the period. This is evident from the solid-line curve in figure 11 and the decreasing slope of the cumulative curve. Still, the total for 1982 was unacceptably high. A check on accidents through much of 1983 indicated that the downward trend continued. The first-quarter total of reportables in 1983 was less than half the first-quarter-1982 total.

Figure 12 shows a more impressive loss reduction trend, in the number of "lost-time" days due to accidental, work-related injuries for each month of 1982. The solid line that connects the monthly data points has a definite downward trend, and the slope of the cumulative curve decreases greatly after midyear. Only about one-fourth of the lost days for the year occurred in the last half of the year. This does not mean that injuries were becoming less "severe" in terms of physical damage, but it does mean that the actions of the safety and loss control foreman and the

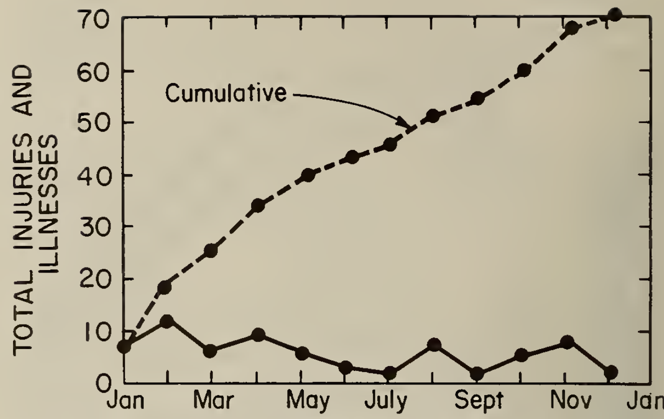

FIGURE 11.—Monthly MSHA reportable injuries and illnesses at company E, 1982.

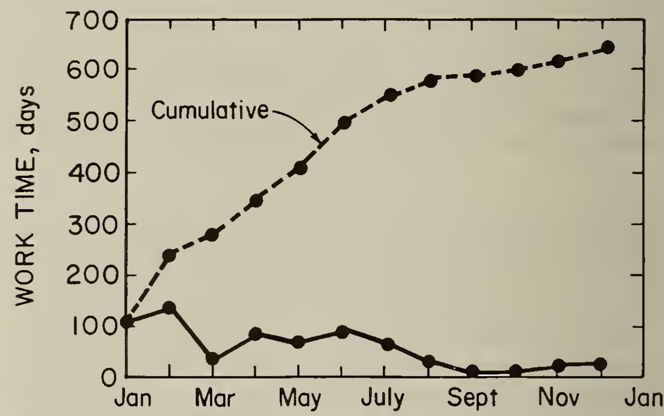

FIGURE 12.—Monthly work days missed by company E employees because of work-related injuries, 1982.

general manager to control post-injury events produced substantial reductions in the "severity measure" defined in 30 CFR 50.

MINING COMPANY W

The results for the six job performance samples taken at company W are given in table 5 and shown on the graph in figure 13. The initial P_T was very high (0.864). In nearly 9 out of every 10 jobs sampled, the employee was working with 1 or more of the 3 types of deficiencies. Substantial improvements began immediately upon implementation, in P_B and P_C as well as in P_A. The rate of improvement increased greatly after July 1982. In July and August, the resident manager established several new rules about personal protection equipment use and housekeeping practices. The enforcement of these rules accounted for much of the increased rate of improvement in P_A. The small increase in P_B between January and April was likely due largely to very harsh February and March weather. The very large decrease in P_C was a result of almost continuous improvements in the work environment at the crushing facility, the mill, and the maintenance shop; coupled with improvements in the haul road and maintenance yard in the last half of 1982.

Figure 14 shows the approximate 95-pct confidence limits for each estimate of the work force population proportion Π_T Again, the solid line (Π_T) is the same as P_T in figure 13 except that the scales of the abscissa and ordinate have been changed.

Table 6 lists the recommednations included in the tailored model for company W, the point value assigned to each, and the points attained. The maximum attainable score was 3,200. The 80-pct attainment level, previously established as the criterion for judging effective implementation, was 2,560 points. The actual attainment by company W was 2,305 points, or 72 pct of the total attainable.

The recommendations are self-explanatory as listed or are explained in the examples in appendix B. One, however, may deserve additonal explanation because it relates to a safety committee: "Create and use management-worker safety committee." The safety committee concept was not a specific feature of the model because it was not regarded as essential to effective health and safety management.

TABLE 5.—Job performance sampling results, Company W

Month	Sample size (n)	Proportion of jobs with deficiencies, by type[1]							
		P_A		P_B		P_C		P_T	
		n_a	Factor	n_b	Factor	n_c	Factor	n_t	Factor
October 1981	66	54	0.818	27	0.409	39	0.591	57	0.864
January 1982	70	52	.743	24	.343	32	.457	54	.771
April 1982	56	34	.607	20	.357	20	.357	39	.696
July 1982	60	31	.517	19	.317	21	.350	36	.600
October 1982	58	12	.207	13	.224	11	.190	15	.259
January 1983	68	8	.118	12	.176	7	.103	13	.191

[1] $P_A = \frac{n_a}{n}$ $P_B = \frac{n_b}{n}$ $P_C = \frac{n_c}{n}$ $P_T = \frac{n_{(a \text{ or } b \text{ or } c)}}{n}$

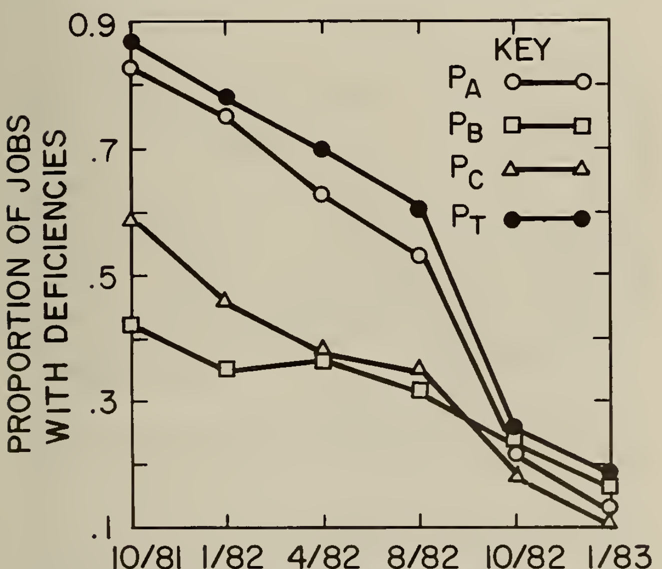

FIGURE 13.—Proportions of jobs sampled at company W in which deficiency types P_A, P_B, P_C, P_T were observed.

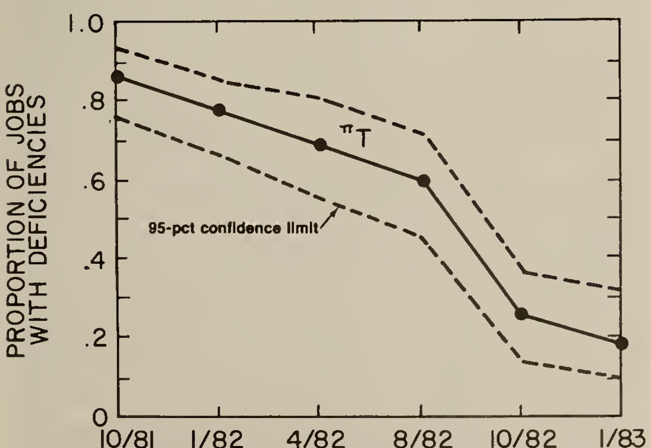

FIGURE 14.—Job-deficiency 95-pct confidence limits for π_T at company W.

TABLE 6.—Recommendations in tailored model for company W

Recommendations	Assigned points[1]	Attained points
Train and stress loss control management	100	75
Integrate safety and production in each job definition	100	25
Identify and require superintendent responsibilities in safety and health	100	65
Improved supervision of correct tool use in shop	50	40
Acquire tool and require haul truck driver to remove rocks between dual tires	50	30
Prohibit Peterbilt dumping in jackknife position	50	50
Install seat belt correctly on forklift trucks	50	50
Keep gate to cyanide storage area closed	50	45
Improve storage of blasting materials	100	95
Acquire and use machines to clear jams in crusher and hopper	100	100
Require safety hat use by supervisors and workers	100	85
Top managers to—		
Set example	100	80
Budget safety time	100	30
Review investigations	100	60
Observe and give reinforcement	100	50
Require near-miss investigations and discussions	100	50
Install bumper blocks at crusher hopper	50	50
Install backguard on crusher hopper	50	50
Provide and use machine seat safety belts	50	50
Improve housekeeping:		
Mill	100	80
Laboratory	50	40
Crusher	100	80
Shop	100	80
Remove extraneous material from machine cabs	50	40
Improve roads, berms, and dumps	100	90
Redesign and maintain runaway ramps	100	20
Add apron to shop	50	40
Construct machine "ready line"	100	70
Add bridge crane to shop	100	80
Create and use management-worker safety committee	100	80
Train and direct: No pushing of machines with loader bucket teeth	50	20
Train supervisors and worker members of safety committee in accident investigation	100	90
Stop low flying of airplane over mine building	50	50
Provide communications, transportation, and water supply for security man	100	75
Improve methods of providing and servicing personal protection equipment	100	70
Improve visitor control and training	100	90
Improve recordkeeping and reporting	100	40
Improve task training	100	60

[1] Points assigned by research team as basis for evaluation.

However, in the case of company W, there were several factors which led to a safety committee recommendation. They were, in approximate order of importance:

1. A short time before the model program implementation began, the company had a union representation election. Among the workers complaints, during the union organizing effort, were those related to inadequate safety and poor management-labor communications. These complaints persisted after the election (in which union representation was defeated). At least two of the leaders of a group highly critical of managment were advocates of a management-worker committee.
2. Three of the supervisors subordinate to the resident manager were clearly managers of the autocratic type. The research team hoped, through training, to encourage the supervisors to try a supportive style. The management-worker safety committee would serve as a workshop for developing such a style.
3. The resident manager was interested in developing any feedback mechanism that would help him understand the concerns of the workers.

He accepted the recommendation for a committee with safety responsibilities, but as it developed, it became a management-worker committee with several other kinds of responsibilities as well.

Figure 15 gives the number of work-related injuries and illnesses in each month of 1982 that were reported as required by 30 CFR 50. In 1981, company W did a very poor job of recordkeeping and reporting. Recordkeeping was addressed early in the model implementation training, but the responsible superintendent did not take followup control action. The majority of the reports were not submitted until long after the 10-day reporting period specified in 30 CFR 50. There was no downward trend of significance in the incidence rate; ten "reportables" occurred in the first half of the year and nine in the last half.

Figure 16 shows the number of "lost time" days in 1982 due to work-related injuries. The days lost for a given month on the graph are not the days lost during the month, but the total days lost at any time due to an injury in that month. For example, there was only one injury in June (fig. 15), but it resulted in more than 100 lost days – obviously not all in June. Clearly the last half of the year was an improvement over the first half. Only approximately one-third of the lost days for the year were in the last half. This is apparent from the cumulative curve. Some of the reason, undoubtedly, was management actions to control post-injury events, as at company E. But how much that effort contributed to the improvement depicted by the graph cannot be determined.

It has been noted earlier in this report that the occurence of accidental injuries is a probabilistic matter. It is also appropriate to view the severity of injuries as a probabilistic matter. During the evaluation process at company W, the research team recorded several instances of management action to track the post-injury events with a view to getting employees back to work as soon as possible. Actions of this type were not common previously – management had accepted almost without question an "excusal note" from any person with a medical profession title, or even an oral statement from the injured person. The new control procedures certainly did what they were intended to do in some cases: They got people back to work and off worker compensation sooner. "Severity," as measured by the 30 CFR 50 method, was reduced, and the employer's loss due to injuries

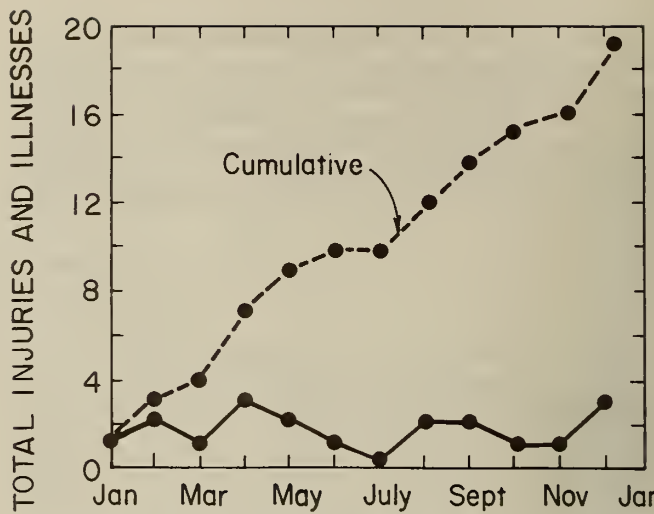

FIGURE 15.—Monthly MSHA reportable injuries and illnesses at company W, 1982.

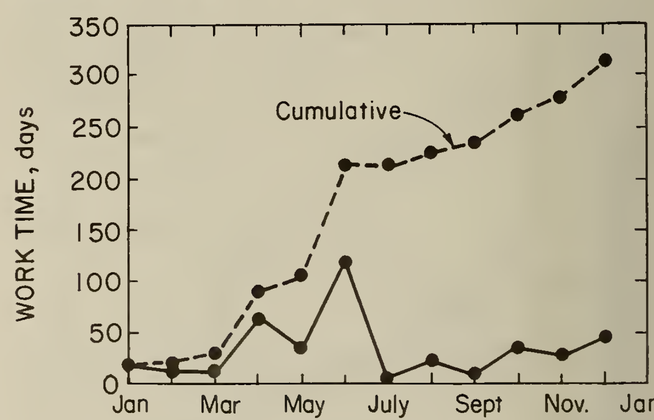

FIGURE 16.—Monthly work days missed by company W employees because of work-related injuries, 1982.

was reduced. Whether the actual physical severity of injuries was reduced is not known.

The research team tried, as part of its model program implementation assistance, to stimulate supervisory interest in careful investigation and recording "noninjury" accidents and near misses. However, the results fell short of expectations. Two of the superintendents appeared initially to regard proper investigation and reporting of injuries as onerous tasks that detracted from their ability to supervise their subordinates. In time, the utility of proper investigation and reporting became apparent to managers, but the superintendents seemed reluctant to extend their acceptance to noninjury accidents. Several months passed before reliable accident information began to flow to the resident manager – and this occurred only after he had made the matter a special subject at management meetings and had issued several written directives. Thus, the recorded data about equipment and facility damage accidents are not complete. However, working from the records that were made and from information collected informally and confirmed officially, it was possible to prepare graphs and tables. About 56 "noninjury" accidents occurred in 1982; this number was certainly the majority of the total accidents. Figure 17 shows the number of accidents by month of occurrence, except that the number shown for February (15) is actually for

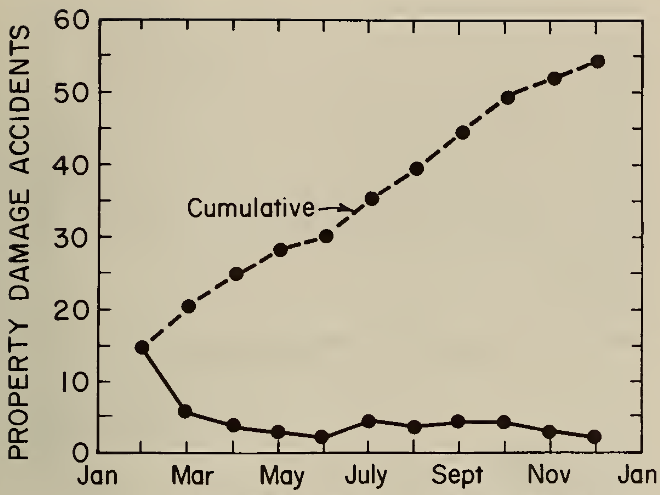

FIGURE 17.—Accidents resulting in equipment and/or facility damage at company W, 1982.

January and February. There were several accidents for which the exact date could not be determined with certainty. The monthly average for March through December was approximately four accidents. For the year, there were at least three times as many noninjury accidents as there were injury-producing accidents.

Table 7 gives some cost information about the 56 accidents represented in figure 17. The "minimum direct cost" is the lowest available estimate of the cost of parts and labor to make necessary repairs. The minimum direct costs were provided by the maintenance superintendent, who obtained them from maintenance records which identified time charges for mechanics and parts withdrawn from shop stock or acquired from the warehouse for each repair job. The minimum direct costs do not include direct supervisory labor costs, the wages of operators paid for periods of idleness due to accidents, or the value of lost production when machines were not available for production use. Also, no "indirect costs" appear on the table. Examples of these are indirect supervisory labor; loss due to partial use of machines because of poor line balancing, as when a shovel is damaged and its haul trucks are assigned to another shovel that already has enough trucks; and the cost of delays in the mining plan, as when blast hole preparation is delayed for several shifts because accidental damage to a drill has taken the drill out of service. An effort was made to determine a reliable estimate of the total accountable costs of the 56 accidents. There were detailed discussions of the accidents and their consequences with supervisors and workers. The estimate finally developed was $235,950 of uninsured loss (not covered or deductible).

TABLE 7.—Accidents resulting in equipment and/or facility damage, 1982

Machine type	Noninjury accidents	Minimum direct cost[1]	Production shifts lost
Rock trucks	10	$ 5,050	4
Ore haulers	8	11,925	26½
Shovels	4	38,250	33
Loaders	4	7,300	14
Graders	4	3,325	8
Bulldozers	4	750	1½
Drills	7	7,500	10
Compressor-generator	2	250	0
Pickup trucks and administrative vehicles	13	5,350	0
Total	56	$79,700	97

[1]Operator wages and lost production value not included.

Following the reasoning used in the management training, it could be said that if company W was to achieve a planned profit of, say, 15 pct on operations in 1982, there would have to be an increase in the planned product sales of approximately $1,573,000 to "pay for" the unplanned costs of the accidents. (This reasoning is explained in the previous section, "Implementation of the Model Program.")

The expectation model mentioned earlier (also in the implementation section) was used extensively in instruction and demonstration at company W. (It was used at company E also, but less frequently.) Two examples based on this model, one simple and one rather complex, are discussed in the following paragraphs.

Early in the implementation, during a management training session, a foreman asked how a simple expectation calculation might be used to bolster the effort to encourage wearing of safety hats. Several of the supervisors attending the course were asked to give examples, from their own experiences, of injuries that probably would have been prevented if the worker had been wearing a safety hat. A list of several such injuries was made, and estimates of the cost of each were discussed. A consensus estimate of the minimum cost (C) of such accidents at company W during a year was developed, along with a consensus estimate of the probability (p) of their occurrence. These estimates, C = $2,650 and p = 0.4, were used to calculate the expected cost if no corrective action (A_1) were taken (some workers not using hard hats) as follows:

	p	C
No corrective action, injuries occur	0.4	$2,650
No corrective action, injuries do not occur	.6	0

$$E(A_1) = 0.4(\$2{,}650) + 0.6(\$0) = \$1{,}060$$

The costs to purchase additional safety hats was determined, and $120 was added for "promotion costs." The total cost of the corrective action was estimated to be $600. A consensus estimate of the probability of head-related accidents after taking the corrective action was developed (p = 0.01). Therefore, the calculation of the expected cost if corrective action (A_2) were taken was as follows:

	p	C
Corrective action taken, injuries occur	0.1	$2,650 + 600 = $3,250
Corrective action taken, no injuries occur	.9	600

$$E(A_2) = 0.1(\$3{,}250) + 0.9(\$600) = \$865$$

Thus, the expectation was that it would cost company W $1,060 – $865, or $195 more each year if no corrective action were taken. This $195 cost was equivalent to $1,300 in sales. The expected annual return of $195 on the $600 investment represents a 32.5-pct ROI. The payback period would be slightly more than 3 yr. These are all different ways of saying the same thing, but saying the same thing differently often stimulates interest and supportive discussion.

The second example was a case of eliminating a safety problem by solving a production problem – that is, by "doing the job right." The ore mined by company W is crushed in a plant near the mine before it is hauled approximately 9 miles down the mountains to the leach pad area. The crushing facility is a choke point in the production process. If ore jams the bin or the primary crusher, there can be no ore flow until the jam is corrected. The scheduled crushing facility production is the facility's capacity of 300 mt/h.

Stoppages due to jams mean that some ore will not reach the leach pads as scheduled. Because the leaching process takes a long time, ore delays mean that the final product, dore, may not be produced at the rate projected. Thus, production is lost.

During the initial safety and health audit and job performance sampling, it was observed that crushing facility jams were frequent and that the methods used to clear them were extremely dangerous. For example, a laborer, straddling the jaw crusher mouth while the crusher was operating but not actually crushing, lowered loader bucket teeth on a rope into the jaw through an opening in the jammed ore made by the laborer with a bar. The teeth helped the crusher jaws to "bite into" the large blocks of ore. The laborer did not wear a safety line and often worked alone. If the bucket teeth method did not work, a truck crane was moved into position, and slings were put around the large rocks that would not go through the crusher so they could be lifted out. There were ways to prevent this hazard, by keeping oversize rocks from reaching the crusher. These ways were being studied by company engineers, but they required major new construction. Another way to deal with the hazard was to provide a machine that could clear the crusher and bin. Such machines are readily avalable. The basic design is a hydraulic arm with a hydraulic pick, a bucket, a spade, or claw at the end.

An expectation analysis was based not on the safety problem, but on the production problem. Available records showed that at least 20 h of crusher production time was being lost monthly because of jams 5 months out of 7 and that approximately 10 h was being lost during each of the other 2 months. At 300 mt/h, 20 h of production represented 6,000 mt of crushed ore, which would yield approximately $86,400 in final product, dore. In a year's time, the value of final product lost could be $1,036,800. It was estimated that a hydraulic cleaning machine would reduce the "20-lost-hour months" to 1 in 12, with the other 11 being "10-lost-hour months." Two machines, one for the jaw crusher and one for the feed bin, would cost $99,800. The expectation computation is shown in table 8. $E(A_2)$ is lower than $E(A_1)$ by $227,311, suggesting that the $99,800 investment would pay for itself in 1 yr, and also result in a $127,511 gain in production. And not incidentally, the risks associated with the hazard would be removed. (The ore mined by company W contains more silver than gold, but the silver was not included in these conservative expectation computations.) The hydraulic machines were purchased and installed in September 1982, not because of the analysis in table 8, but because the resident manager and parent company production engineers were working on a very similar production improvement.

TABLE 8.—Expectation computation to add hydraulic pick and shovel[1] to company W crusher

Eventuality	Probability of occurrence	Annual net cost
Action A_1 (no corrective action):		
20 h/month lost	0.714	$1,036,800
10 h/month lost	.286	518,400
$E(A_1)$[2]	NAp	888,538
Action A_2 (corrective action):		
20 h/month lost	.083	1,136,600
10 h/month lost	.917	618,200
$E(A_2)$[2]	NAp	661,227

NAp Not applicable.
[1]Cost of hydraulic pick and shovel: $99,800.
[2]Expectation, E(A) = (probability of occurrence) (annual net cost) for situation where 20 h/month are lost to jams plus (probability of occurrence) (annual net cost) for situation where 10 h/month are lost to jams.

The research project manager made the last formal field trip to company W in March 1983. In connection with some training being done for new management people, the "payback" computation in table 9 was made. By that time, there were "before" and "after" data available that could be compared with the estimates used in the earlier expectation model. The computation helped to illustrate the use of the expectation model and to demonstrate a general truth: Frequently a safety problem can be solved by solving a production problem. The payback period in this case was less than 2-½ months.

TABLE 9.—Payback-period computation for hydraulic pick and shovel for company W crusher

	Total time crusher inoperable due to rock jams, h
Prior to installation of pick and shovel:	
Feb. 1982	20.65
Mar. 1982	20.35
Apr. 1982	24.95
May 1982	22.45
June 1982[1]	11.38
July 1982[1]	14.67
Aug. 1982	23.23
Total, Feb-Aug. 1982	137.68
Av, Feb-Aug. 1982	19.67
After installation of pick and shovel (Sept. 13, 1982):	
Sept. 1982	8.68
Oct. 1982	13.07
Nov. 1982	10.40
Dec. 1982	13.64
Jan. 1983	5.02
Feb. 1983	7.00
Total, Sept. 1982-Feb. 1983	57.81
Av, Sept. 1982-Feb. 1983	9.64
Hours "saved" after installation (compared with Feb.-Aug. 1982 av hours inoperative):	
Sept. 1982	10.99
Oct. 1982	6.60
Nov. 1982	9.63
Total, Sept.-Nov. 1982	27.22
Cost (in production hours) of hydraulic machinery[2]	23.10

[1]Tonalite ore.
[2]Hours of production = cost of hydraulic machines ($99,800)/value of production ($4,320/h). Value of production = scheduled production (300 mt/h) × gold content (0.06 oz/mt Au) × gold price ($400/oz Au). Since the average number of hours of production lost per month was 9.64, and the cost of the hydraulic equipment was equivalent to 23.10 h of production, the payback period = 23.10 h ÷ 9.64 h/month = 2.40 months.

WORK FORCE COMPARISONS

The evaluation results are somewhat more meaningful if one understands some of the differences in the characteristics of the two work forces. Almost all of the company E employees grew up in the region of the mine and live less than 50 miles from their work, but only a very small fraction of the comapny W employees are natives of the region where that company is located. Nearly all of the company E employees call themselves miners – their chosen occupation. Most of the company W employees do not call themselves miners. They are machine operators, construction workers, ranchers, laborers, etc., who happen to be working in a mine. The company E employees generally plan to work there as long as they can. Many of the company W employees have plans to go elsewhere at some specific time, usually within a year or two. Several of them are college students, working as miners to get money to use to return to school.

The conventional wisdom is that absentee rates and turnover rates go hand in hand; that is, a mine with a higher

turnover rate will have a correspondingly high absentee rate. A common explanation is that absenteeism is a symptom of job dissatisfaction and that quitting (turnover) is but a stronger manifestation of that dissatisfaction. In the case of companies E W, the company with the higher turnover rate had the lower absentee rate. The absentee data for both companies in 1982 are given in table 10. The overall absentee rates would have been very nearly the same in both companies had it not been for two union-related phenomena at company E: strikes and "paid personal leave." The labor contract for company E contains a provision that each worker is authorized 3 days a year of paid absence, called "personal leave." These are really three additional vacation days, although they are not thought of in that way by the workers. As one would expect, every hourly worker takes the three paid leave days. These days are included in the "absent" line in table 10. They represent nearly as many hours absent (approximately 7,400 h) as the grievance strikes. Together these two phenomena accounted for approximately 15,500 h absent, or nearly 7½ worker-yr.

TABLE 10.—Overall absentee rates, 1982

	Company W	Company E
Hours:		
Scheduled	233,925	760,150
Worked	226,804	722,812
Absent, total[1]	7,121	37,347
Absent due to strikes[2]	NAp	8,120
Percent of scheduled hours absent	3.04	4.91

NAp Not applicable.
[1]Includes all reasons except holidays and vacations.
[2]Illegal grievance strikes.

Figure 12 showed the "lost days" due to work-related injuries in company E. The 1982 total was 639 days, or 5,112 h. This number is only 13.7 pct of the total hours absent in 1982 for company E (table 10). Figure 16 showed the "lost days" due to work-related injuries in company W. The 1982 total was 329 days, or 2,632 h. This number is 37 pct of the total hours absent shown in table 10 for company W.

Table 11 gives the 1982 turnover data for both companies. Company W, with only one-third the number of employees in company E, replaced 80 pct more employees during 1982. Company E replaced approximately 1 employee in 10. Company W replaced nearly 6 in 10. Company E's turnover rate was mostly a result of involuntary termination: the company was discharging people who had the poorest job performance and reliability records. Company W's turnover rate was related more to voluntary terminations, although that company was also discharging many employees who had poor job performance and reliability records (more than 2 out of every 10 employees).

TABLE 11.—Work force turnover, 1982

	Company W	Company E
Average total employment	340	113
Turnover[1]	35	63
Total turnover rate ... pct..	10.3	55.8
Voluntary turnover rate ... pct..	1.5	34.5
Involuntary termination rate ... pct..	8.8	21.2

[1]Number of persons whose employment was terminated and for whom replacements were hired.

The turnover in management positions was high at both companies. By mid-1982, all company W supervisors on the payroll at the time (the resident manager, the three superintendents, and four key foremen) had received some of the model program training. Less than a year later, only the resident manager and one foreman who had been demoted to a nonsupervisory job remained on the payroll. Excepting the top manager, there had been 100-pct turnover in management. At company E, the management turnover was not as large, but was still significant. The top manager, the preparation plant foreman, and the surface drilling foreman were discharged in April 1982, when model program implementation was just getting "up to speed." The surface maintenance supervisor (master mechanic) resigned a few months later. It is tempting to speculate that the model programs at both companies would have been even more effective if management turnover had not been so high.

WORK-RELATED ILLNESSES

Before the model program was introduced, neither company E nor company W devoted much attention to keeping records of illnesses that may have been job related. Attention to these records was still lacking during the model implementation and evaluation. The data the research team was able to acquire came mostly from two sources: workers compensation claims and interviews with workers who had been absent or had required medical attention, or both, due to an alleged job-related illness.

Tables 12 lists all of the illness cases at both companies about which information was obtained. The cases are placed in the codes given in 30 CFR 50.6(b)(7) for reporting on the MSHA form 7000-1. The three columns in table 12 titled "Claimed," "Verified," and "Reportable per 30 CFR 50" reflect actions taken to sort out those claimed illnesses that should be reported to MSHA. 30 CFR 50.2(b) reads, ("'Occupational illness' means an illness or disease of miner which may have resulted from work at a mine or for which an award of compensation is made." The part about an award of compensation is clear enough, but the phrase "may have resulted" is more difficult to work with. The first thing management must do is determine whether the illness or disease claimed actually exists. If a medical authority verifies the illness or disease, or if the miner is observed to

TABLE 12.—Claimed job-related illnesses, companies E and W, 1982

	Claimed	Verified	Reportable per 30 CFR 50
Code 21, occupational skin diseases or disorders:			
Chemicals	1	1	1
Coal	1	0	0
Fuels and lubricants	1	1	0
Codes 22 and 23, dust disease of the lungs and respiratory conditions due to toxic agents:			
Dust (other than coal)	2	0	0
Coal dust	1	0	0
Chemicals	1	1	1
Welding fumes	3	1	1
Code 24, poisoning:			
Lead	2	0	0
Mercury	2	0	0
Cyanide and other	2	0	0
Code 26, disorders associated with repeated trauma:			
Pain[1]	2	1	0
Personal protection equipment irritation	1	1	0
Code 29, all other occupational illnesses:			
Alcoholism[2]	4	4	0
Stress[2]	5	5	0

[1]Possibly noise related.
[2]Not usually considered job-related illnesses. Not covered in 30 CFR 50.20-6.

be ill or in pain, there is seldom any further question. If neither a medical opinion nor information from direct observation is available, management usually assumes that the illness or disease is ficticious. Sometimes, even with verification and acknowledgment that the illness may be work-related, there remains a question about the reporting requirement. An example is the "fuel and lubricant" case in table 12, under code 21. On a Friday, a mechanic was working with some special lubricant. An hour or so later he developed a rash on his hands, arms, and parts of his face. The container for the lubricant carried a warning about the possibility of skin irritation. First aid was administered. The mechanic continued to work through the shift. Saturday and Sunday were not scheduled workdays for him. He returned to work on Monday. The rash had almost cleared up. The illness was not reported on MSHA form 7000-1, although there was some argument among managers about whether it should have been.

The six code-24 poisoning cases were the subject of extensive medical analyses which concluded that the illnesses did not exist. Company management wanted very much to know the truth so that the health protection procedures could be changed if necessary. It is possible that the workers may simply have feared that they had, or were about to have, medical problems and were seeking the truth, too. The claims occurred very soon after some health training for mill and laboratory workers had been completed and management had begun a rather elaborate environmental monitoring procedure. Not long before, MSHA had cited the company for lack of adequate controls, protection equipment, and monitoring. Several workers had made alarmed inquiries about their health risks to MSHA.

The several cases of alcoholism and stress were included under code 29, although there were many differences of opinion about that, too. One of the participating companies, and its parent company, sent two of the alcoholics to receive special treatment for several weeks each. The treatment was very expensive, but apparently also very successful. One of these treated workers retired because of heart disease a couple of months after he returned. The other one was working well, through the end of the model program evaluation. The other two reported alcoholics have never received any treatment, as far as is known. Their employers, the participating companies, did not offer them help apparently because they never acknowledged that they had a disease and never asked for treatment.

The five stress cases were verified by observation and the statements of the affected employees, although only one of them ever used the word "stress." One haul truck operator had two minor equipment-damage accidents on a single night shift. The safety official, who knew him well, rode with him for an hour or two following the second accident. The operator rather suddenly "blurted out," "I can't keep my mind on the job." He then told of several serious family problems and how his work obligations affected his ability to deal with them. Another equipment operator was distraught to the point of sobbing and vomiting. After a long talk he said, "I am making myself sick with worry." The operator said he worried about his relationship with his supervisor and the possibility that the company would be sold and the supervisor would get a promotion that would make his situation even worse. (The parent company had publicly announced an intent to sell the company if an acceptable offer was received. It was also true that the supervisor had threatened the employee with discharge if the supervisor received the promotion he was trying to get.) During the research, it was observed that where the autocratic style of management was practiced, there seemed to be a higher incidence of stress and stress-related health problems than where the supportive style was practiced.

PROJECT OVERVIEW

Much time was devoted to understanding each company. More than 90 worker-days of the researchers' time were spent at company W; this was approximately equivalent to one person's presence every working day for 4.3 months. More than 170 worker-days were spent at company E, the equivalent of one person's presence every working day for 8 months. The employees of both companies cooperated fully with the researchers. There were no restrictions of any kind on where or when the research project manager went about the property, what he did, what he photographed, or to whom he talked. Any record requested was promptly made available. Thus, the researchers have a great deal of confidence in the validity of their findings.

Implementation Time Requirements

Although the model program may seem quite ordinary and simple, its implementation represented a very substantial change in management style and emphasis at the two participating companies. This may explain why it took much longer to put the concepts into practice and to achieve a reasonable semblance of the five previously described fundamental conditions than the research plan allowed. The time required was much greater than either the research team or the company managers estimated. The managers of companies were well educated, capable, diligent, and stable people, but they were not thoroughly trained in management. It took them more than 6 months to put the model program concepts into practice. Nine to twelve months would probably be the minimum time required for full implementation in most mines, large or small.

Using a Reifier

The word "reifier" relates to materializing ideas, that is, making them real. The preferred mode of performance for person acting as a reifier is to bring up questions, assemble and report facts to management, facilitate communication, and teach. Although it is not essential that a reifier be used to help implement the model program, there are several advantages to using one. A major advantage of using a reifier is that the program will probably be implemented significantly sooner than if a reifier is not used. The minimum amount of time a refier would be needed to assist the top manager with program implementation is about 60 h. However, generally, the reifier would be very helpful to most managers for the full period of implementation.

CONCLUSIONS

The model program described in this report is a very basic program about managment. It deals with essential conditions only. As stated in the introduction, the intent of this project was to identify and correctly define only those health and safety program elements that have potential for universal application throughout the mining industry.

The costs of implementation are low because implementation mostly involves getting management people to do better what they are already being paid to do. It is not harder work that is required, but "smarter work." Because implementation is inexpensive and the loss reduction is very substantial, the benefit-to-cost ratio is quite favorable.

Not all of the improvements reported herein were made solely because of the model program implementation. Many of the improvements unquestionably would have occurred in the absence of the model program. Management's own initiative, the parent companies' influence, MSHA activities, and employee suggestions and criticisms all contributed in varying degrees. In the view of the researchers, it did not matter how an action got started. What mattered for evaluation purposes was whether the action was compatible with the model program concepts and what the result was.

The dramatic improvements observed at both companies during the course of this study strongly suggest that if the model program described herein is thoroughly understood and conscientiously implemented, it will significantly reduce injuries, illnesses, equipment damage, production losses, and other unplanned costs.

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APPENDIX A.—EXCERPTS FROM TAILORED MODEL PROGRAM, COMPANY E

1. Comment: The majority of the (mining company E) people with whom there were discussions reflected views of safety (and loss control generally) as a consideration distinctly separate from, and sometimes in conflict with, production.

   Recommendation: Such views should be changed through top management direction, loss control training of supervisors, and regular discussions of the cost and other productivity-related facts of accidents and near misses at management meetings.

   Management decision: Recommendation accepted.

   Priority: 1 yr

   Points: 100

2. Comment: The jobs at both worker and working foreman levels are not clearly and fully defined in writing, with health and safety aspects integrated with other performance expectations. It is apparent that the present management policy is to integrate production and safety considerations in each job. The introduction to the (mining company E) "Safety Guide" states, "It is not our intent to place the well-being of our employees secondary to production considerations. Rather, it is our objective to incorporate good work procedures and practices into each work phase."

   Recommendation: It is essential that supervisors define exactly the performance expectations of each job. Make plans to prepare a written job definition for every job. For mobile machine operators, the manufacturer's operating instruction manual serves well as a foundation. But these manuals must be supplemented by local production procedures, State and MSHA standards, company policies, and other related information. For other jobs, a job description should be prepared with the participation of workers and supervisors.

   Management decision: Recommendation accepted.

   Priority: 1 yr.

   Points: 100

3. Comment: Several (mining company E) supervisors appeared to believe that the safety officer has the primary responsibility for safety and health matters, and that their own responsibilities (the supervisors') are primarily for production.

   Recommendation: A safety officer position, full or part-time, should—

   - Be filled by a person qualified by experience, training, personality, and interest in the work. (The present part-time safety officer appears to be so qualified).
   - Report directly to the general manager. (The present safety officer position reports in this way, according to the organizational chart).
   - Have a title such as "assistant for loss control" or "assistant for safety, health, and security," indicating a direct relationship with the responsibilities commonly assumed to be a "safety officer's job".
   - Have a written job description that makes clear that the primary responsibility for safety, health, and loss control rests with line supervisors; that the duties of this job are those which augment the top manager's capability to deal with loss control policy and supervision; and that the official provides technical assistance to the line managers in carrying out their responsibilities.
   - Be clearly defined in terms of the percentage of time that will be devoted to safety, health, and loss and, if not full-time, have clearly defined additional duties and related reporting channels.
   - Have a salary range that reflects the top management expectations with respect to productivity and profitability contributions.

   Management decision: Recommendation accepted.

   Priority: 3 months

   Points: 100

4. Comment: There were some work practices observed at (mining company E) that had a high probability of producing personal injury or other losses. Their existence provides evidence that supervisors (and workers) do not have highly developed safety awareness and that safety is not always given the same emphasis as "getting on with the job." In most cases, job production would be improved if the job was done in a better (safer) way.

   Recommendation: The specific work practice examples A, B, and C, described below, should be corrected by appropriate supervisors. In addition, these examples should be used in training sessions, not to criticize individual actions, but to emphasize the risks of poor work practices and the need for careful job definition and close supervision.

   Management decision: Recommendation accepted.

   Priority: Example A, 100
   Example B, 100
   Example C, 100

   Example A: 30 CFR 75.523-2 requires that self-propelled electric face equipment be equipped with a bar or lever for quick de-energizing of the tramming motors. The bar or lever can move only 2 in, with no more than 15 lbf necessary to cause de-energizing. The bar or lever is commonly called the panic bar.

On three of the five electric underground machines checked during the safety audit, the panic bar did not

de-energize the machine. The primary reason was bending or other distortion of the bar assembly, which rendered it incapable of depressing the panic button.

It is a very dangerous practice to fail to maintain emergency equipment. Emergency devices should function reliably on those infrequent occasions when they are needed if serious consequences are to be avoided. All such equipment should be inspected and tested by the operator at the start of each shift, and repaired as necessary.

Example B: The company "Safety Guide" has the following rule on page 4: "Fire fighting equipment shall be maintained at all times on heavy equipment. Extinguishers which have been discharge should be reported to the foreman." During the safety audit, several fire extinguishers on machines were observed to be partially discharged. Apparently machine operators are not inspecting and reporting regularly.

Example C: Arc-welding operations were being conducted in a room that contained flammable refuse and liquids. The welding was not well ventilated or shielded, a violation of 30 CFR 77.408, as well as generally recommended industrial practice and the parent company's "Safety Rule Book."

5. Comment: Most subordinate supervisors have not received specific training in loss control management or otherwise devoted time to study or think about this subject. Generally, subordinate supervisors will emulate the example set by the top manager. They may be induced to not merely support, but to lead health, safety, and general loss control management activities through a combination of training and repeated encouragement by the top manager.

Recommendation: Schedule loss control training for salaried and hourly supervisors. All supervisory personnel should participate. The top manager's participation is especially important. He can provide reinforcing and clarifying comments, especially those related to his own plans for operations. His active role in discussions will encourage others to participate, thereby enchancing the learning experience for everyone, including the instructor.

Management decision: Recommendation accepted.

Priority: 6 months

Points: 100

Several other excerpts from company E's tailored model program are given in the final project report *(2)*.

APPENDIX B.—EXCERPTS FROM TAILORED MODEL PROGRAM, COMPANY W

1. Comment: The jobs at both worker and working foreman levels are not clearly and fully defined in writing, with health and safety aspects integrated with other performance expectations.

   Recommendation: Make plans to prepare written job definitions for every job. For mobile machine operators, the manufacturer's operating instruction manual serves well as a foundation, but these manuals must be supplemented by local production procedures, State and MSHA standards, company policies, and other related information. For other jobs, a job description should be prepared with the participation of workers and supervisors.

   Management decision: Agree with recommendation. The research team will prepare drafts, working from references, comments of workers on what they perceive their jobs to be, and comments of working foremen. The draft will be reviewed and supplemented or otherwise modified as appropriate by superintendents. The final drafts will be reviewed and approved by the resident manager.

   Priority: 9 months

   Points: 100

2. Comment: A formal policy statement of the manager's commitment to safe operations is a necessary, but not sufficient, manifestation of such commitment. Subordinate supervisors and workers judge the manager's true concern for health, safety and general loss control primarily from observation of his actions.

   Recommendation: The resident manager should influence the "safety climate" (at mining company W) through the following actions:
   - Always wearing personal protection equipment (hard hat, safety glasses, safety shoes, and hearing protection, in high-noise areas) whenever he is outside of his office.
   - Budgeting his time so that he devotes at least 10 pct of his normal work week (4 h) to participation in loss control activities. Specifically, he should–
     a. Conduct periodic health and safety "spot" inspections.
     b. Lead at least one departmental worker safety meeting each month. Explain policy changes and future plans and discuss recent accident and near misses. Encourage comments and suggestions from the workers, write them down, and report later what action was taken on each.
     c. Visit the scene of every accident and discuss the circumstances with those involved in a "fact-finding, not fault-finding" mode.
     d. Observe workers performing their duties. compliment those who are working safely and acting to reduce losses (positive reinforcement). Suggest or demonstrate changes in work practices to those who are not working safely and acting to reduce losses.

   Management decision: Agree with the recommendation and will implement immediatly.

   Priority: 1 month

   Points: Set example, 100
   Budget safety time, 100
   Review investigations, 100
   Observation and reinforcement, 100
   Near miss investigations, 100

3. Comment: The most obvious, and perhaps the most serious, hazards are at the crushing plant. Two, for example, are related to the design of the primary crusher feed hopper and its grizzly, which stops some rocks that should pass and passes some that should not be passed. Thus, there is a rock removal task and a crusher clearing task, which are hazardous. On two occasions, workers were observed clearing a jam in the primary jaw crusher at the crushing plant. Each time the task took nearly 2h–2h during which no ore moved through the plant. The task was done by a laborer straddling the operating crusher mouth and using a bar and bucket teeth on ropes as his tools. He wore no safety line. This is not only a very dangerous way to clear the crusher, but also a very inefficient one. Several serious injuries were inflicted on workers using a bar in an operating crusher in 1980, and at least one of them was at an installation of company W's parent company. This is an example of a very hazardous work practice made "necessary" by poor facility design and failure to provide proper tools for the task. There is no "bumper block" or other restraint to keep the loader from being driven into the grizzly. There is no back guard or rear apron on the hopper to reduce the possibility of rocks bouncing off the grizzly and onto equipment and workers below in the primary crusher area. (The area is roped off at ground level to discourage trespass some of the time).

   Recommendation: Management should make removal or reduction of the obvious hazards a top priority. (Mining company W) and (parent company) engineers were working on crushing plant production problems in November. Detailed discussions with the engineers indicated that they understood the hazards described and would include plans for their removal or reduction in their overall facility improvement plans. This is a case in which sound solutions to the production problems will also solve many of the safety problems.

   Priority: 9 months

   Points: 100

4. Comment: Some machines require seat belt maintenance before actions to encourage seat belt use can have any meaning. For example, (one truck) has the seat belt improperly mounted (to the frame rather than to the spring seat). (Another truck) has a seat belt only on the passenger seat. Several machines have installed belts which are very dirty and in very poor condition.

Recommendation: Inspect all machines for properly installed seat safety belts.

Management decision: Agree with recommendation.

Priority: 1 month

Points: 100

5. Comment: Dump areas and haul roads need good berms to reduce dumping and hauling hazards. Less stable dump areas, such as on recently dumped top soil, need higher and wider berms than more stable dump areas. Steep haul roads require good "runouts," or deceleration ramps (soft or hard), for emergencies such as brake failure. Generally, waste dump maintainers were observed to maintain berms well, but there were several exception. The top soil dump berm was not as wide or high as it should be in some places. Several short sections of steep haul road are without berms. Some of the deceleration ramps on the main road between the crusher and leach area are of questionable design (too steep, too short, etc.), and a few had the approach obstructed by the results of grader or snow plow work.

Recommendation: State in writing, a clear policy on berm construction and maintenance on dumps and haul roads. Have an engineering analysis of the deceleration ramps done. Make any design and contruction changes indicated by the analysis.

Assure that all bulldozer, grader, and loader operators who construct berms are trained to make them at least as high as the axle of the largest truck at (mining company W).

Management decision: Agree with recommendations.

Priority: 6 months

Points: Berms, 100

Redesign ramps, 100

Several other excerpts from company W's tailored model program are given in the final project report (*2*).

APPENDIX C.—JOB PERFORMANCE SAMPLING

The job performance sampling procedure, one of the means used to evaluate the model health and safety program, is discussed in several sections of this report. This appendix is intended to give the reader more details about the procedure. The next page contains the form used to record observations. On it are given short explanations about how the samples were selected and what information was recorded. Sample entries are given on the right side of the form. On the pages following the sample form are examples of each of the three types of deficiencies that were recorded during the sampling.

Job Performance Sampling Form

Job information	Observer's instructions	Sample entry
Sample No.	(Systematic sampling used: every kth worker, with a random start. Note time.)	#8 10:20 a.m.
Job	(The job title and the type, model, and company number of the machine operated, if job is machine operator.)	Truck driver, CAT 777, #60351
A Personal preparation	(Deficiencies in things for which the worker has sole responsibility. For example, proper clothing; safety shoes, safety hat, safety glasses, ear protection, and other special protection items required by the job, including safety belt use; clean windows and mirrors, clear cab, etc.)	Hard hat in poor condition; needs replacement soon.
B Equipment and tools	(Deficiencies in things that worker alone cannot correct. Improper tool or equipment and machine condition. Preshift inspection checklist items plus others of special interest. Actions indicating poor task training, assignments, or supervision.)	1–Lenses on right and center white backup lights broken. 2–Fire extinguisher on deck needs repair; extinguisher on floor of cab.
C Work procedures	(Observe work 5 to 10 min, or cycle of machine operation. Note deficiencies in environment, procedures, practices, work sequences, and especially hazards–things called unsafe acts and unsafe conditions, and not included in A and B. Generally, poor methods and conditions which relate to more than one job.)	1–Backed into loading point before loader had indicated desired position. 2–Berm along haul road to upper waste area C inadequate–too low and not continuous.
Comment	(Preliminary evaluation of importance of deficiency not previously noted or noted but not corrected, and action that should be taken and by whom. Optional for all except "imminent danger" items.)	C1: Corrected on spot by foreman. C2: Foreman told motorgrader operator to correct by end of shift. and B1 and B2: Maintenance scheduled repair of lenses and extinguisher mount for night shift. A foreman to arrange issue of new hard hat next day shift.

Examples of Type A Deficiencies (Employee Correctable)

1. Wearing improper clothing on the job.
2. Failure to wear safety shoes in good repair.
3. Failure to wear safety helmet in good condition.
4. Failure to wear safety glasses where required.
5. Failure to wear seat safety belt.
6. Failure to use a safety line where required.
7. Failure to wear hearing protection where required.
8. Failure to have self-rescuer on belt underground.
9. Failure to keep operator station and deck of underground machine clear and clean.
10. Failure to use installed lights on mining machine.

11. Failure to use water spray at face.
12. Failure to move trailing cable correctly.
13. Failure to use correct tool or part.
14. Using machine incorrectly (for example, pushing another vehicle with bucket teeth).
15. Speeding.
16. Failure to yield right of way to loaded trucks.
17. Failure to follow any task performance rule posted or included in training or direction.
18. Keeping hand on roof drill while turning drill.
19. Moving truck with body raised.
20. Dumping truck with wheels turned or body not level.
21. Unsafe handling of batteries.
22. Improper use of compressed air.
23. Improper care of welding lines and hoses.
24. Opening acetylene cylinder valve more than one turn.
25. Failure to keep compressed-gas cylinders upright and secured.
26. Improper use of wire rope clamps and thimbles.
27. Poor housekeeping in workplace.
28. Improper use or storage of ether-based starting fluid.
29. Improper disposal of salvagable items.
30. Improper disposal of pressurized containers.
31. Smoking in prohibited area.
32. Carrying smoking materials underground.
33. Drinking alcoholic beverages on property.
34. Using recreational drugs on property.
35. Failure to wear special protection equipment required for task.
36. Operating a machine for which not trained and qualified.
37. Unauthorized reading material in machine cab or other workplace.
38. Failure to cut power and lock out before working on circuits.
39. Failure to conduct proper inspection of machine each shift.
40. Failure to report machine or equipment defects.
41. Failure to keep windows, light lenses, and other glass clean.
42. Tardiness in reporting to job.
43. Failure to report an accident or near miss.
44. Misuse of tools, equipment, or emergency supplies.
45. Failure to block machines raised by jacks for repair.
46. Failure to conduct a proper shutdown check.
47. Moving ahead of supported roof.
48. Loading or unloading moving mantrip or supply cars.
49. Failure to stop conveyor and lock out before working on it.

Examples of Type B Deficiencies (Employer Correctable)

1. Failure to provide safety hat.
2. Failure to provide suitable safety glasses.
3. Failure to fit, repair, and replace personal protective equipment.
4. Failure to install seat safety belts correctly.
5. Failure to replace damaged or very dirty seat belts.
6. Failure to maintain ladders on surface machines.
7. Failure to provide ear protection and hygiene training.
8. Failure to provide safety lines and belts.
9. Failure to repair reported machine defects.
10. Failure to provide correct tools or parts.
11. Assigning worker to task for which he or she has not been trained.
12. Directing worker to use incorrect tool, defective machine, or badly demaged equipment.
13. Failure to post traffic rules.
14. Failure to maintain workplace lighting.
15. Failure to train worker for tasks specifically part of job.
16. Failure to provide appropriate hazard training (for example: in use of compressed air and ether-based starting fluid).
17. Allowing short cuts not permitted in job definition.
18. Failure to perform required workplace and machine inspections.
19. Failure to report and act on tardiness or absence.
20. Ignoring accident or near miss reports.
21. Ignoring evidence that worker is ill, "hung over," or otherwise partially incapacitated.
22. Failure to correct improper performance of task.
23. Failure to provide, and check periodically, lock out devices.

24. Allowing workers to move under unsupported roof.
25. Failure to require proper preparation for underground welding (with respect to fire extinguisher, rock dust, etc.).
26. Permitting welding, drilling, or cutting ROPS supports.
27. Permitting work on live electrical circuits.

Examples of Type C Deficiencies (Common to Several Jobs; Employer Correctable)

1. Failure to monitor noise level in suspect area.
2. Failure to install noise suppression or require hearing protection in high-noise area.
3. Failure to check escape tunnels, etc., regularly.
4. Failure to require berms at dumps and along haul roads.
5. Allowing deviations from approved roof control plan.
6. Failure to conduct appropriate air contamination measurements.
7. Permitting hazardous practices to be specified as normal practice in work procedure definition.
8. Inappropriate truck queuing procedure at load points.
9. Inadequate fire-suppression and emergency medical capability available.
10. Inadequate policy for emergency management on holidays and weekends.
11. Failure to specify proper personal protective equipment for every job in the work procedures.
12. Failure to fully and correctly inform workers of any existing environmental or atmospheric conditions which may represent hazards to their health or safety.
13. Failure to provide proper security for workers' personal property and autos.
14. Failure to provide safe mantrips.
15. Failure to provide adequate area lighting.

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